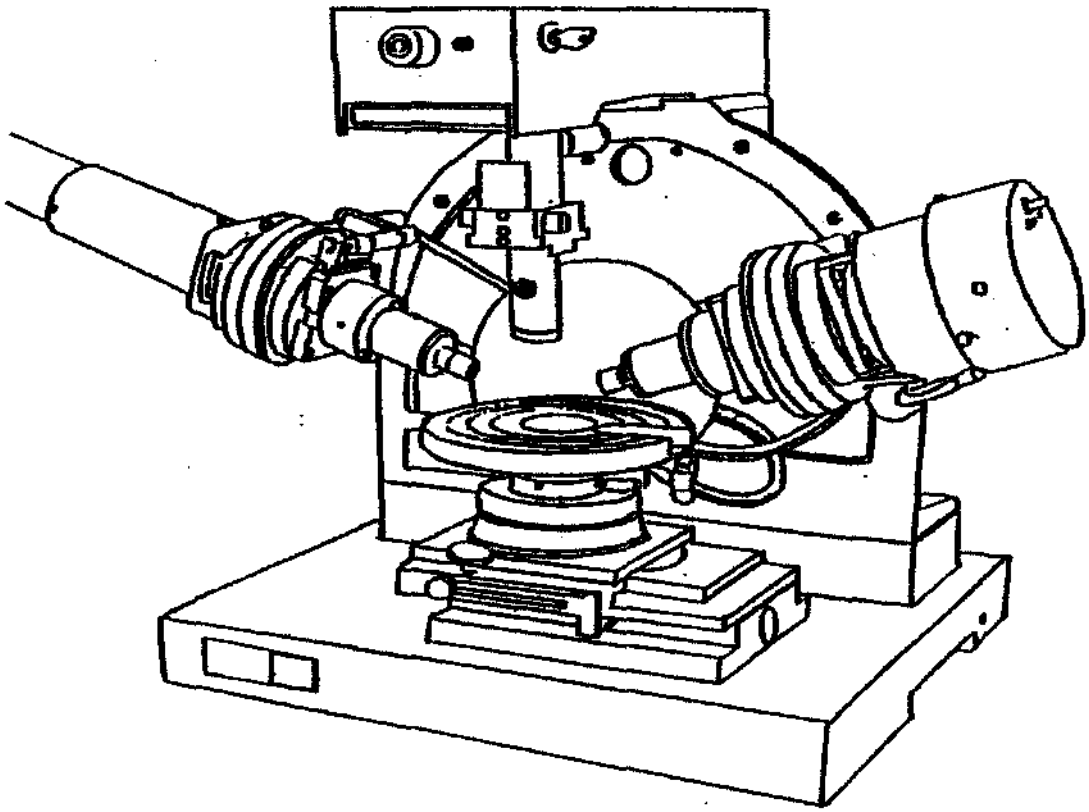
INSTRUCTIONS
FOR
L116C ELLIPSOMETER

7109-C229D



GAERTNER SCIENTIFIC CORPORATION

3650 W. Jarvis Ave., Skokie, IL 60076 USA TEL: 847 673 5006 FAX: 847 673 5009

www.GaertnerScientific.com

WARRANTY:

ALL OPTICAL AND MECHANICAL COMPONENTS OF THE L116C ELLIPSOMETER ARE WARRANTED FOR TWO YEARS FROM DATE OF DELIVERY. ELECTRONIC COMPONENTS, INCLUDING THE LASER, ARE WARRANTED FOR ONE YEAR. ANY DEFECTS IN MATERIAL OR WORKMANSHIP WILL BE CORRECTED BY GAERTNER AT NO COST, INCLUDING SHIPPING CHARGES. TRAVEL AND LODGING COSTS INCURRED BY SERVICE PERSONNEL ARE NOT COVERED BY THIS WARRANTY. WARRANTY ON DEFECTS IN MATERIAL OR WORKMANSHIP FOR COMPUTER EQUIPMENT SUPPLIED WITH THE L116C ELLIPSOMETER IS WARRANTED BY THE COMPUTER MANUFACTURER AND THEIR STANDARD WARRANTY CONDITIONS APPLY. THE COMPUTER MANUFACTURER WILL, AT THEIR OPTION, REPLACE EQUIPMENT THAT PROVES DEFECTIVE DURING THE WARRANTY PERIOD. REPAIRS NECESSITATED BY THE MISUSE OF THE EQUIPMENT, INCLUDING THE USE OF SOFTWARE OR INTERFACING NOT SUPPLIED BY GAERTNER, ARE NOT COVERED BY THIS WARRANTY. NO OTHER WARRANTY IS EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTY OF MERCHANTABILITY AND SUITABILITY FOR A PARTICULAR PURPOSE.
GAERTNER SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES.

LASER SAFETY

GOVERNING REGULATION

The **Gaertner L116C Ellipsometer** has a helium – neon laser light source. The accessible radiation does not exceed one milliwatt and, therefore, is classified as a Class II laser product as defined by **Radiation Performance Standards 21CFR, Subchapter J (Federal Register, Volume 10 #148, July 31, 1975)**. Appropriate **WARNING** and **Conformance labels** are affixed to the ellipsometer to alert personnel of the presence of laser radiation during operation.

WARNING Logotype.

Attached to the polarizer arm and reads: **LASER RADIATION. DO NOT STARE INTO BEAM.**

APERTURE Label.

Attached to the exit aperture of the polarizer module and reads: **AVOID EXPOSURE. LASER RADIATION IS EMITTED FROM THIS APERTURE.**

CERTIFICATION Label.

Attached to the left front face of the vertical plate and reads: **THIS LASER COMPLIES WITH DHEW / CDRH RADIATION PERFORMANCE STANDARDS 21CFR SUBCHAPTER J.**

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

1.0 SPECIFICATION

Net Weight (approx.)	30 kg (65 lbs)
Shipping Weight	43 kg (95 lbs)
Dimensions (approx.)	
Height	45.7 cm (18 inches)
Width	83.8 cm (33 inches)
Depth	38.0 cm (15 inches)
Laser Light Sources (less than 1 mW accessible radiation)	632.8 nm Helium – Neon Red Laser
Incidence Angles, Pre – aligned (detent)	50° and 70° are used the most. See the next page
Beam Diameter (std.) 1 mm	1.0 x 1.6 mm at 50° 1.0 x 3.0 mm at 70°
Compensator	Quarter – wave plate; fast axis at +90° to plane of incidence
Polarizer / Analyzer	360° graduated at 1° intervals with 10- part vernier (0° to 1°)
Sample Size	Up to 150 mm (5.9") dia. to 10 mm max thickness
Method of Measurement	Dual mode (with and without the compensator in the laser light path); the polarizer drum fixed at 45°; the rotating analyzer samples 144 data points.
Film Thickness Range	0 to 60, 000Å (0 to 6,000 nm)
Accuracy	± 3 Angstroms (± .3 nm)*
Repeatability	± 1 Angstrom (± .1 nm)*
Refractive Index	± 0.005*
Line Voltage	115Vac (50 – 60Hz) std; 100Vac, 220Vac, 230Vac or 240Vac are available
Standard Program	See Section 3 of this Manual.
Optional Programs	See Section 4 of this Manual.

* **Over most of the measurement range.**

1.0 SPECIFICATIONS (Continued)

This ellipsometer has the detented angles of incidence in the table below for measurement purposes. There are also detents for **90°**, but this angle is only for adjustments.

ϕ	Standard Beam on Sample	Microspots* Beam on Sample
30°	1 mm x 1.15 mm	15 μm x 17.2 μm
45°	1 mm x 1.15 mm	15 μm x 21.1 μm
50°	1 mm x 1.55 mm	15 μm x 23.2 μm
55°	1 mm x 1.74 mm	15 μm x 26.0 μm
60°	1 mm x 2.00 mm	15 μm x 30.0 μm
65°	1 mm x 2.37 mm	15μm x 35.5 μm
70°	1 mm x 2.92 mm	15μm x 43.8 μm
75°	1 mm x 3.86 mm	15μm x 57.9 μm
80°	1 mm x 5.76 mm	15μm x 86.3 μm

*** The Microspot Optics are optional components for the polarizer and analyzer arms. See the Optional Components Section.**

2.0 ABBREVIATIONS AND SYMBOLS

Nf Real value of refractive index for film being measured

Kf Extinction value of refractive index for film being measured

Ns Real value of refractive index for substrate

Ks Extinction value of refractive index for substrate

Φ **(PHI)** Angle of incidence

ψ **(PSI)** Amplitude ratio as determined by measurement

Δ **(DELTA)** Phase difference as determined by measurement

A/D Analog – to – digital

ADJ Adjust

AEC Analyzer to Electronic Chassis

AMPL Amplifier

AS Autoset

A/AUTO Automatic

cm Centimeter

CTL Control

DET Detector

EBT Encoder – buffer turnoff

LED Light emitting diode

LSB Least significant bit

M / MAN Manual

mm Millimeter

MSB Most significant bit

nm Nanometer

PCTL Peripheral Control

PD Photodetector

PFLG Peripheral Flag

P/O Part of

PWR Power

RECT Rectifier

REF Reference

SPLY Supply

STD Standard

SW Switch

W/O Without

3.0 INTRODUCTION

This section describes the components of the ellipsometer and shows how the ellipsometer analyzes the Effect of reflection on the polarization of the laser light striking the surface of materials, such as bare substrates, (as in Figure 1 – 1, next page) to acquire measurement data identifying properties critical to quality control. Interpretation of the data yields the optical constants of the material or, if the material surface is film – covered, the thickness and optical constants of the film. Once initiated by the user, analysis and measurement are automatic, utilizing a programmed, desktop computer interfaced with the ellipsometer. Parameters are entered by the user via the computer keyboard. Queries requiring operator / computer interaction and actual measurement data are displayed on the computer screen. Measurement data may be printed for a permanent record.

4.0 OPTICAL SYSTEM (See Figure 1 – 1, next page)

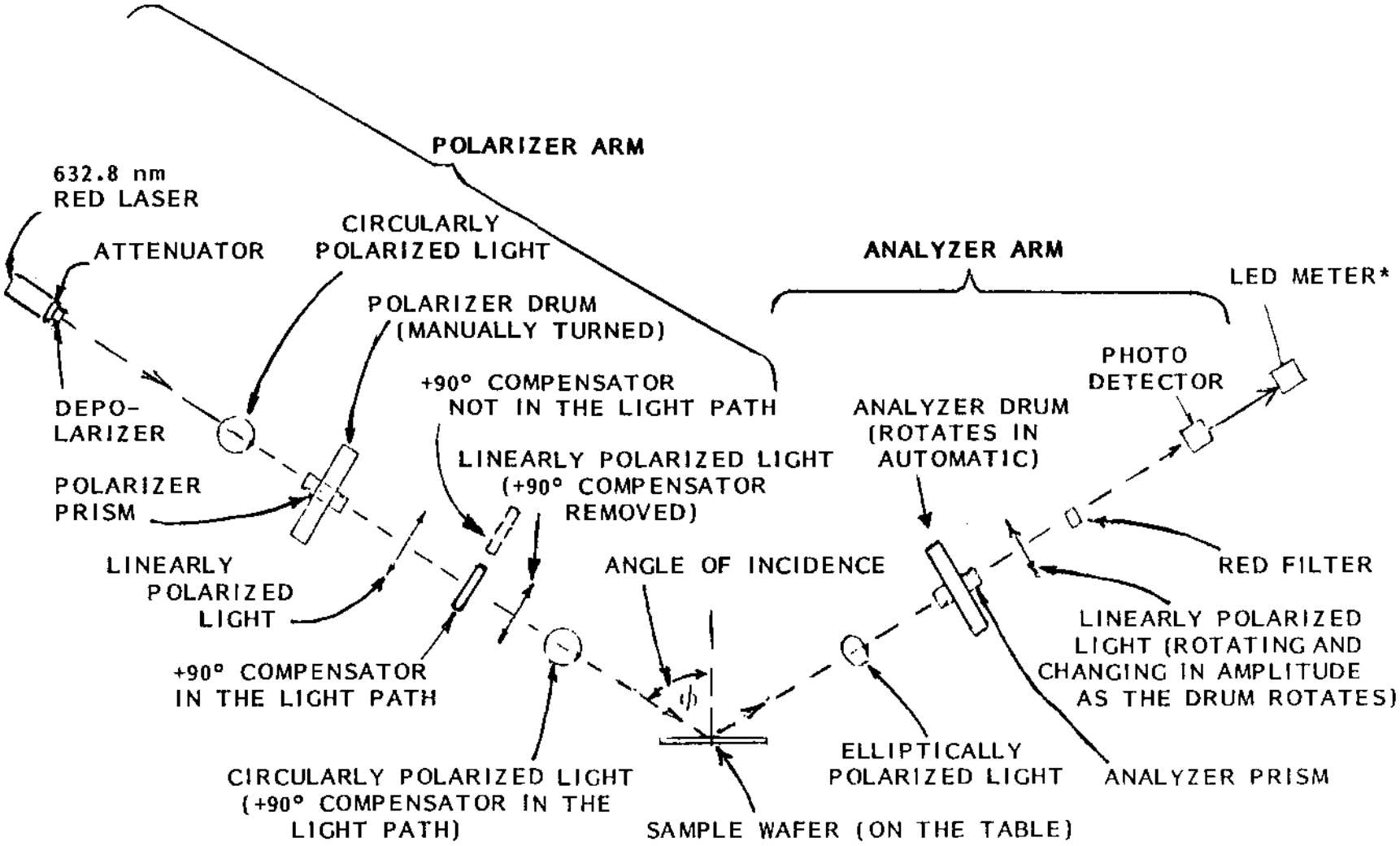
Ellipsometric measurements involve illuminating the surface of a sample wafer with monochromatic light of known wavelength and polarization and then analyzing the polarization state of the reflected light. The light is projected along a fixed path or angle of incidence (ϕ). The ellipsometer has pin – located settings for the angle of incidence at **30°**, **45°**, **50°**, **55°**, **60°**, **65°**, **70°**, **75°**, **80°** or **90°**. The **90°** angle cannot be used for measurements, only adjustments.

For measurements, the angle of reflection is always set at the same angle as the incidence angle. Since the two angle are always equal, it is usual to refer to both angles as angles of incidence. With the angles thus set, their respective optical axes intersect the vertical center line of the plane of incidence at the same point. The sample table is raised or lowered so that the intersection of the incidence and reflective optical axes is on the sample surface, and that the sample surface is normal to the vertical centerline of the plane of incidence. This ensures that the light from the polarizer aperture is reflected from the sample surface into the analyzer aperture.

A low – power (Class II) laser – light source is employed; a helium – neon laser having a beam wavelength of **632.8 nm**. The **632.8 nm** (**red**) laser is in the line of the optical axis; and as the beam passes through a polarizer prism, the beam polarization is converted from circular to linear.

This constant – intensity, linearly – polarized beam is then converted to one of circular polarization when a quarter – wave compensator is inserted in the optical path, or remains linear when the compensator is withdrawn from the optical path. The insertion and withdrawal of the **+90°** compensator is automatic, under computer program control. The resultant beam, with or without the **+90°** compensator in its path, is then projector upon the surface of the sample wafer.

The reflected light, with its polarization altered by the optical properties of the sample, passes through a rotating analyzer prism (in a rotating drum) and is then sensed by a photodetector which, in turn, converts the light energy into an electric current proportional to the intensity of the reflected light passing through the analyzer. An optical interference filter between the analyzer prism and the photodetector blocks all of the wavelengths other than that of the laser beam, thus eliminating the effects of ambient illumination.



*The LED meter is not on either arm.

Figure 1-1 This is the Optical System Functional Diagram for a single-wavelength ellipsometer.

5.0 ELLIPSOMETER COMPONENTS

The principle components of the **L116C** Ellipsometer are identified in Figures 1 – 2 and 1 – 3.

5.1 Laser

A red laser assembly, with a fixed wavelength of **6328Å** (**632.8 nm**), is adjusted to provide the low – power (Class II, which is for under one milliwatt) light source. A built – in quarter – wave depolarizer in the laser output produces a circular polarization of the beam.

NOTE: When the beam attenuator (see below) is out, the laser beam strikes the sample wafer or table surface, both the polarizer and analyzer arms **must** be at the same angle of incidence. Then the ellipsometer can make measurements and will be safe to work with. The beam attenuator on any laser supplied to **Gaertner** is removed when the laser output is adjusted to under one milliwatt.

5.2 Polarizer (See Figures 1 – 1 and 1 – 2).

Polarizer Drum and Prism. The polarizer prism, mounted in the polarizer drum, is a **Glan Thompson** calcite prism that converts the circularly polarized light from the laser to linearly – polarized light. Any given angle of prism orientation from **0°** to **360°** can be set by adjusting the polarizer drum. The angle can be set to within tenths of a degree by setting a number in whole degrees (indicated on the drum) just below **zero** (**0**) on the **0** – to – **1** vernier scale and then aligning a graduation on the vernier scale to one on the drum scale. For automatic measurements, the user should fix the polarizer drum at exactly **45°** by inserting the locking screw into the drum's detent.

Compensator. The compensator assembly is at the optical output of the polarizer prism, and has a mica, quarter – wave plate, set at **+90°**. When this way plate is put in the laser light path, the linearly – polarized light from the polarizer prism is changed to circularly polarized light.

Beam Attenuator. The beam attenuator (more accurately called a " **beam blocker** " lever, at the polarizer module output aperture, is a manually – operated slide device to either block the incident beam or to allow passage of the beam to the sample surface.

5.3 Sample Monitor Assembly

The Sample Monitor Assembly has both a tilt monitor and 39 – power, sample surface – viewing microscope. Using the viewing scope function, the user can see the sample surface for damage or imperfections. The light source for the surface illumination is built – in, originating within the sample monitor assembly enclosed in a housing above the objective end of the sample monitor. The intensity of illumination is charged by turning a control on the left side of the Sample Monitor Assembly.

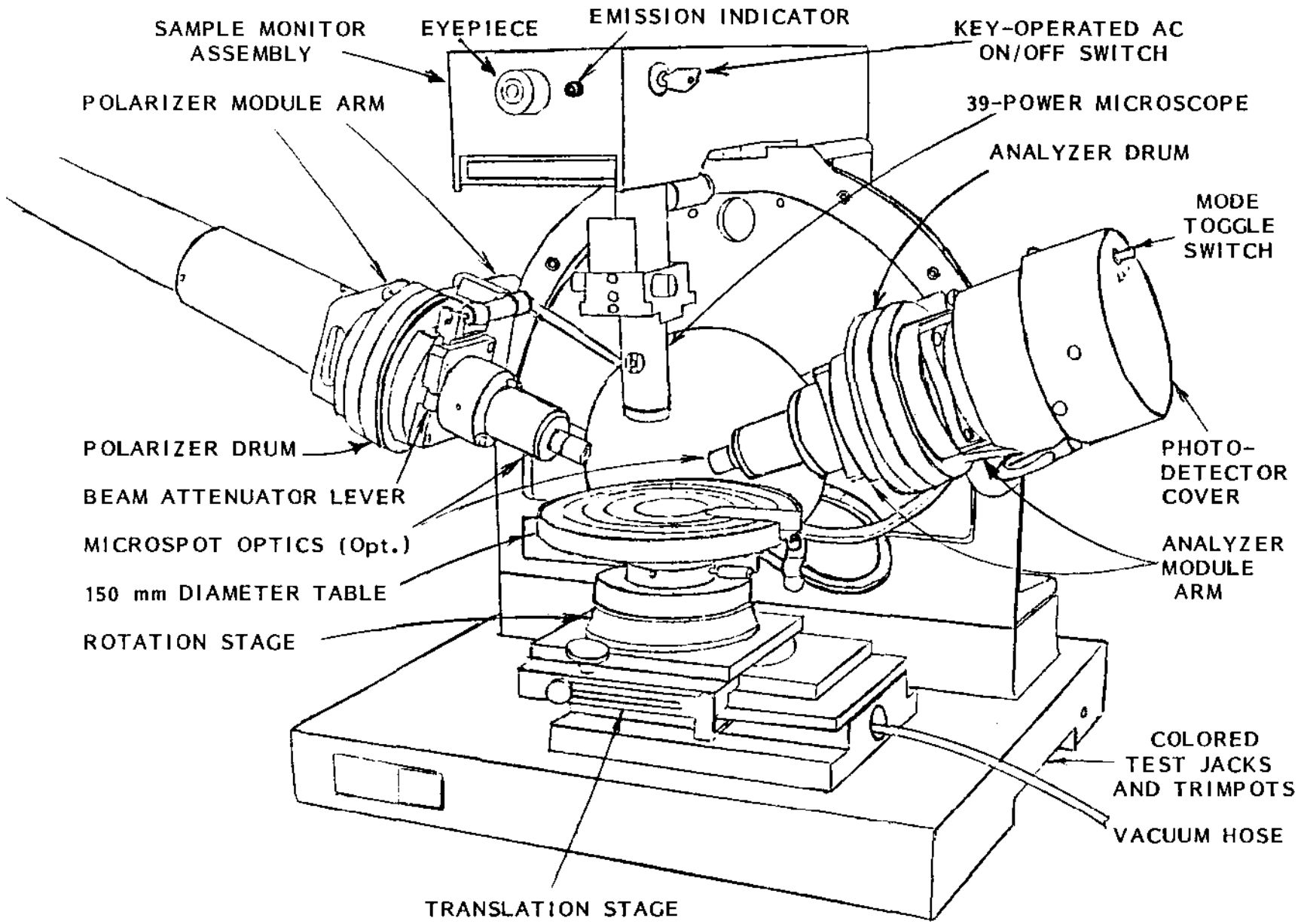


Figure 1-2 These are the front-view components of the Ellipsometer L116C.

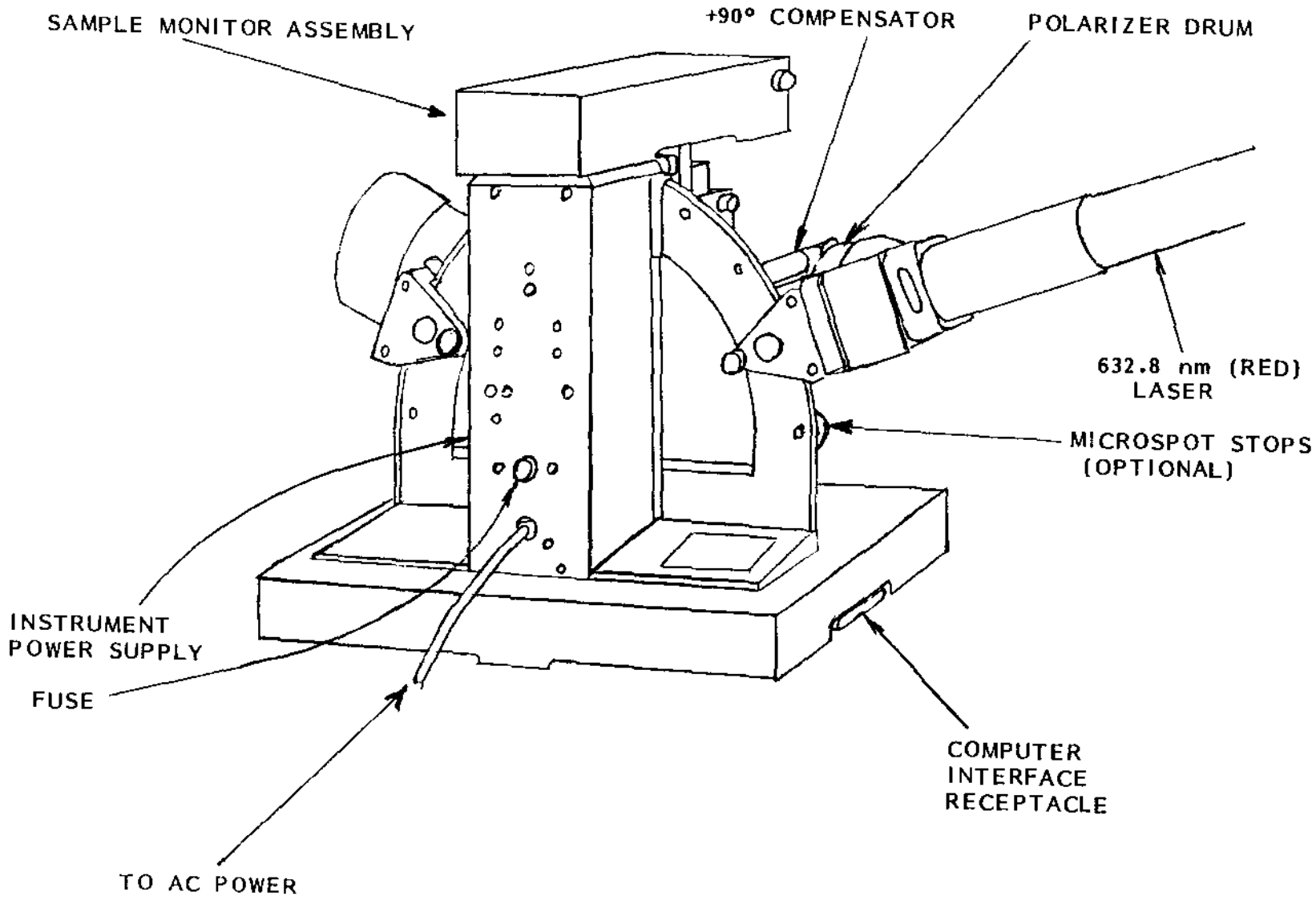


Figure 1-3 These are the Ellipsometer L116C Components in this Rear View.

5.3 Sample Monitor Assembly (Continued)

Using the tilt monitor function, the operator can detect an out – of – flatness condition of the sample surface and compensate for this condition. The amount of out – of – flatness is determined by observing a reflected image projected as background on **90 – degree** crosshairs in the eyepiece. Compensation is accomplished by tilt adjustment of the sample table in **X** and **Y** planes. The tilt adjustment controls are on the underside of the table. The Sample Monitor Assembly includes the following:

- **LED Meter**
- **Emission Indicator**
- **Electrical Control Group**
  - **Key – operated ellipsometer and laser power (ON / OFF) switch**
  - **Illuminator and illumination intensity control**

5.4 Reference Sample

A silicon substrate wafer reference sample with a single – layer transparent silicon oxide film (thickness of about **780Å**, which is **78 nm**) is supplied with the ellipsometer. Initially, the sample should be used for obtaining sample measurements in the process of instrument familiarization. Periodically, the sample should be used to obtain measurement data for comparison with previous data to verify that the ellipsometer is in proper adjustment.

5.5 Analyzer

Analyzer Drum and Prism. The analyzer prism is in the analyzer drum and in the optical axis of the light reflected from the Sample Wafer (Figure 1 – 1). The analyzer prism is identical to the polarizer prism in that it is a **Glan Thompson** prism inside a motorized drum. During automatic operation, the analyzer drum (with the analyzer prism inside) is constantly rotated by the drive motor. Encoder and optical switch assemblies on the analyzer shaft are slotted such as to allow the passage of light pulses at discrete intervals of the analyzer rotation, from **LED's** to phototransistors which, in turn, generate the pulses used during the measurement process.

Filter. A narrow – band, **632.8 nm** (**red laser**) optical interference filter is installed at the analyzer output, and is used to block all of the wavelengths except that of the laser beam.

Detector and Switch Assembly. This unit is inside the photodetector cover with an access hole and consists of a solid – state photodetector that produces an output current proportional to the intensity of the light from the analyzer prism; a current – to – voltage converter / preamplifier; analog output amplifier; and three – position Mode Switch.

5.6 Electronic Chassis

This assembly is in the ellipsometer base and consists of the analyzer motor drive, analog / digital conversion, test jacks and interfaces to the computer.

5.7 Instrument Power Supply

This assembly is in the vertical enclosure, at the rear of the support frame. The power supply provides the conversion of various line voltages, compensator control and laser drive.

5.8 Sample Stage and Table

The sample stage provides a combination rotary and linear manual positioning of the sample table, allowing measurement at any point on the sample surface. This is achieved by linear translation in the (+) **X** direction from center and rotation from **0°** to **360°** . The linear scale is graduated in **one** (**1**) **mm** increments, numbered at **10 mm** intervals from **0** to **75 mm** full scale. The rotary scale is graduated in **1°** increments, numbered at **10°** intervals from **0°** to **360°**. See Figure 1 – 2 on page 1 – 9.

The table is vertically adjustable, so that the laser beam reflected from the sample surface is maximized when entering the analyzer aperture. The vertical position is adjusted by rotating a knurled knob on the support structure. (A clockwise rotation raises the table.) A locking screw secures the vertical adjustment.

The standard table will accept samples up to **150 mm** (**5.9"**) in diameter, and is tiltable up to **one** (**1**) degree in both **X** and **Y** planes from the predetermined level position established at **Gaertner** just before the shipment of the ellipsometer. See the description of the Sample Monitor Assembly (page 1 - 8). A fine – motion vertical position adjustment option may be added to the table. An attachment for the vacuum pump is on the right side of the stage. See Figure 1 – 2 on page 1 – 9.

Yellow plastic locator strips are supplied for use in centering a wafer sample on the table surface.

For example: A plastic strip can be inserted into either the **3 - inch**, **100 mm**, **125 mm** or **150 mm** diameter groove in the surface of the standard table.

6.0 DETERMINATION OF PSI AND DELTA

The state of polarization of a beam is determined by the relative amplitude (amplitude ratio) and the relative phase shift (phase difference) between the two component plane waves resolved from the electric field of the beam. If the phase differences between the components is either **0**° or **180**°, the beam is linearly polarized. All other phase differences result in elliptical polarization. When a monochromatic beam of polarized light strikes the surface of a sample, the reflection of the light causes a change in the relative phases of the component plane waves and a change in the ratio of their amplitudes.

The angle **DELTA** (Δ) is defined as a change in phase difference. An angle **PSI** (Ψ) is the arctangent of the factor by which the amplitude ratio changes. The phase difference (Δ) and the amplitude ratio (Ψ) thus characterize the elliptically polarized light reflected from the sample surface. These parameters are used to calculate the optical constants of bare surfaces and, if film covered, the thickness and refractive index of the film. The refractive index **Nf** is used to determine the physical composition of the film and to establish the magnitude of the period, i.e., the thickness interval between the repeating of ellipsometric readings.

Using the measurement data obtained from the two sets of light intensity readings, the computer calculates **DELTA** for each set. The **DELTA** selected, to achieve optimum accuracy in computation of optical constants and film thickness, is based on the following criteria:

- Δ **Within 45° of 0° or 180°, DELTA is found with the +90° compensator in the laser light path.**
- Δ **More than 45° from 0° or 180°, DELTA is found without +90° compensator in the light path .**

PSI is always obtained from the measurements without the **+90°** compensator in the light path.

7.0 STANDARD PROGRAM DESCRIPTION

One standard single – point program (**STD**) is supplied with each ellipsometer that has an **IBM** computer.

The Standard (Single – Point Program, STD (SC6A + SC7A + GC5A + SubCA) is for both **L115C** and **L116C** Ellipsometers. There are four subprograms:

- **GC5A** — **FILM:** This subprogram determines the thickness and refractive index of single – layer, transparent (**non-absorbing**) film of silicon dioxide or silicon nitride on a silicon substrate.
  Data Output: Thickness, Index, PSI (Ψ), DEL (Δ), and the period. There is a fixed index option.

- **SC6A** — **SPECIFIC:** This is similar to the **Film** subprogram. Oxide or nitride films are evaluated at an incidence angle of only **70°**.

- **SC7A** — **TWO ANGLE:** This subprogram for measures the thickness of silicon oxide, silicon nitride or other nonabsorbing film on silicon substrate. Two – angle measurements are at **50°** and **70°** incidence angles. It determines the absolute thickness of thick films based on the order or period from a matched measurement at each angle.
  Data Output: Matched thickness values, Index and a listing for each angle.

- **SubCA** — **SUBSTRATE:** This subprogram determines the optical constants of a bare substrate. These constants must be known before to making thin film measurements.
  Data Output: PSI (Ψ), DEL (Δ), real (Ns) and extinction (Ks) refractive indexes constants of the substrate.

NOTES:

1.0 PREMEASUREMENT SETUP

The premeasurement setup includes setting the polarizer and analyzer angle of incidence, turn – on and the warmup of the ellipsometer, and initial alignment of the sample stage

1.1 Setting the Angle of Incidence

CAUTION

Do not grasp the **632.8 nm** (**red**) laser when setting the polarizer arm. That may easily cause laser misalignment.

a. Grasp the polarizer arm (but **never** the laser); and at the rear of the arm, loosen clamp screw about one turn.

b. Pull outward on spring-loaded locator pin next to the clamp screw, and move the arm to within ¼ - **inch** of the **70°** angle of incidence.

c. Release the locator pin, and move the arm slowly until the pin seats in detent on vertical plate. Tighten clamp screw. (This accurately sets the angle of incidence.)

d. Repeat steps **a** through **c** to set the analyzer arm angle of incidence, but do not apply pressure to the **PD** (**photodetector**) cover.

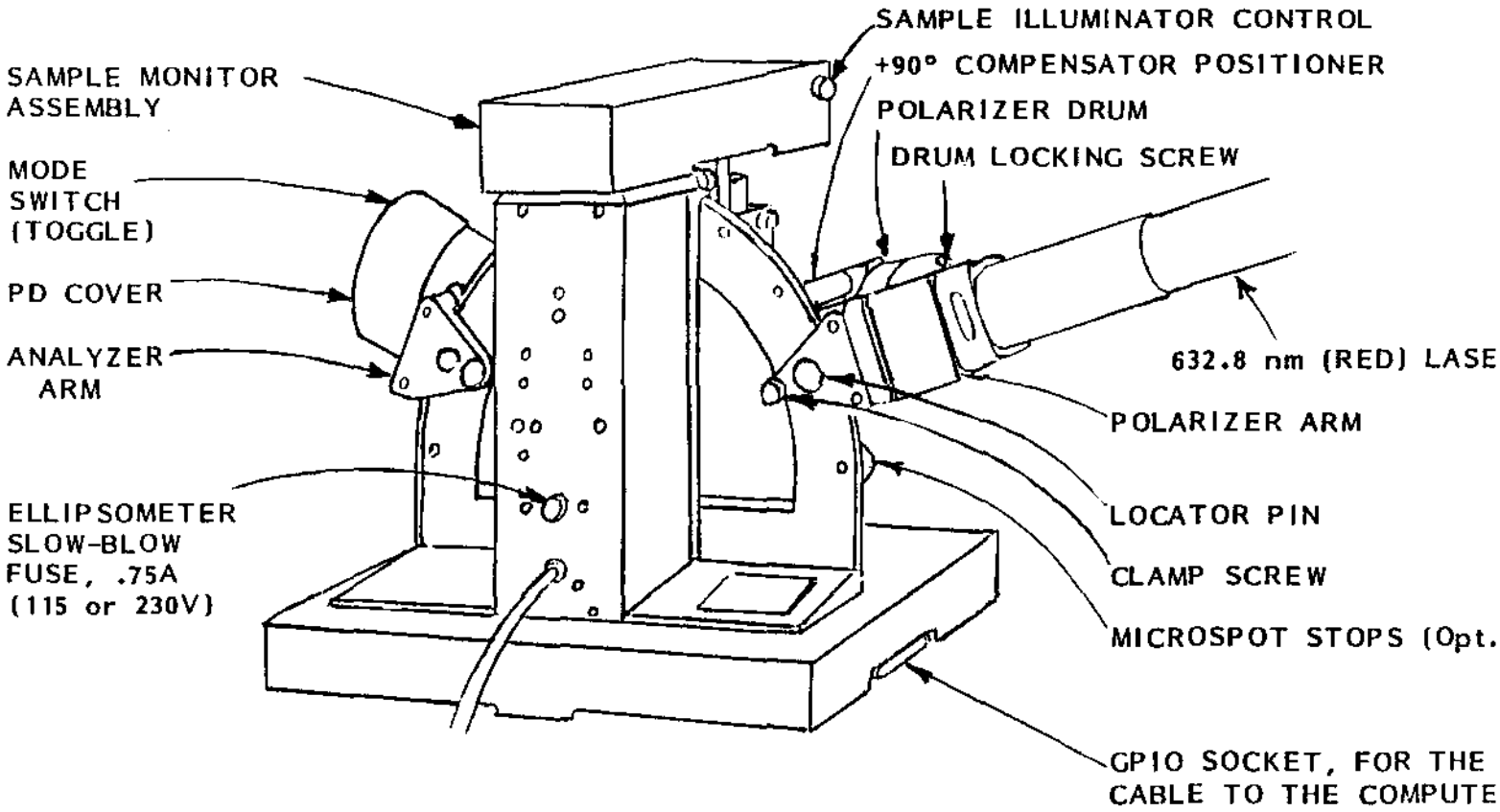
NOTE: Follow steps **a** to **d** also when setting the angle of incidence at any other angle.* The detented angles are **30°, 45°** through **80°** at **5°** steps. There is also **90°**, which is only for adjustments. See page 1 – 4 of the Description section about the beam size at each angle.

e. Set the polarizer drum to **45°**, and secure by inserting the locking screw in the hole on the side of drum.

* See the Caution note at the top of Figure 2 – 1 about the arms with the optional Microspot optics at the **90°** angle of incidence. Note the statement (with the asterisk) just above the caption about the fact that with the microspots, the arms cannot be set at **90°** with the larger table.

CAUTION (For 90° Angle of Incidence)*

If the L116C has Microspot Optics, rotate the 150 mm table so that its lifting slot is under the analyzer Microspot. Move the table to the left and down so that neither Microspot Optic will contact the table when both of the arms are at 90°.



* The optional **200 mm** dia. table cannot be moved out of the way of the optional Microspot Optics. Thus, the arms cannot be set at **90°** with both of these options.

Figure 2 – 1. This is the rear and left view of the L116C Ellipsometer (with the standard table).

1.2 Turn – on and Warmup

a. Connect the ellipsometer and the computer according to the Installation section.

b. To turn on the ellipsometer and the **632.8 nm** (**red**) laser, turn the key – operated power switch on the Sample Monitor Assembly fully clockwise, **ON** (Figure 2 – 2). The Emission Indicator should illuminate. A **15 – minute** minimum warmup of the **632.8 nm** laser is recommended before performing ellipsometeric measurements. Set the Mode (**toggle**) switch (Figure 2 - 1) to **AS**. The following describes the three Mode Switch positions:

- **Manual (M) position:** This is used during alignment and calibration
- **Autoset (AS) position:** This is used during premeasurement setup (Sample Stage alignment)
- **Automatic (A) position:** This is used for automatic measurement (with the Drum rotating)

c. Pull to open the beam attenuator, and proceed with the " Sample Table Vacuum and Alignment ".

1.3 Sample Table Vacuum and Alignment

Vacuum At the center and rear of the table are small (#0 – 80 x 1/8" round head, stainless steel) plugs that can be removed when a vacuum pump is connected to the ellipsometer. Remove only the plugs that will be under the wafer, but not the plug under the edge of the wafer (see Figure 2 – 3).

Alignment Follow this procedure, beginning with step **a** (see Figure 2 – 4).

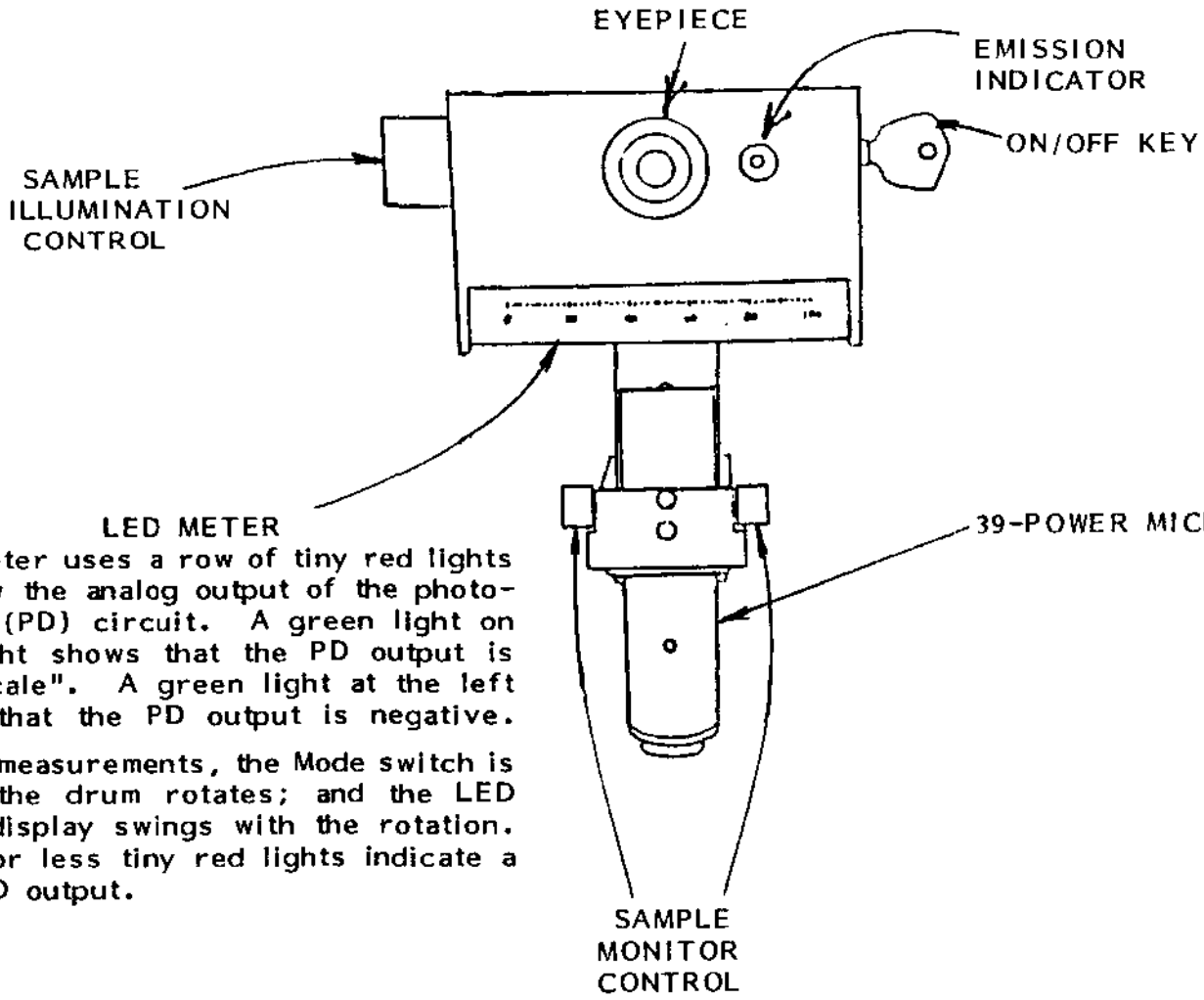
a. With tweezers, air wand, etc. put a reference sample or single – layer, nonabsorbing wafer of a known film thickness on the table via the insertion slot. Turn **on** the vacuum pump if connected.

b. Loosen the Sample table clamp screw.

c. Look into the Sample Monitor Assembly eyepiece, turn the illumination control for the desired illumination. Move the eyepiece **in** or **out** for the sharpest of the **90°** crosshairs.

d. Rotate either of the Sample Monitor Control knobs in Figure 2 – 2 so that it brings a reflected image of the two diagonal lines into view (if already not in view), as seen in the eyepiece.

(Section 1.3 continued on page 2 – 6)



This meter uses a row of tiny red lights to show the analog output of the photodector (PD) circuit. A green light on the right shows that the PD output is "overscale". A green light at the left means that the PD output is negative.

During measurements, the Mode switch is at A; the drum rotates; and the LED meter display swings with the rotation. Three or less tiny red lights indicate a zero PD output.

Figure 2 – 2. These are the ellipsometer controls and indicators on the Sample Monitor Assembly.

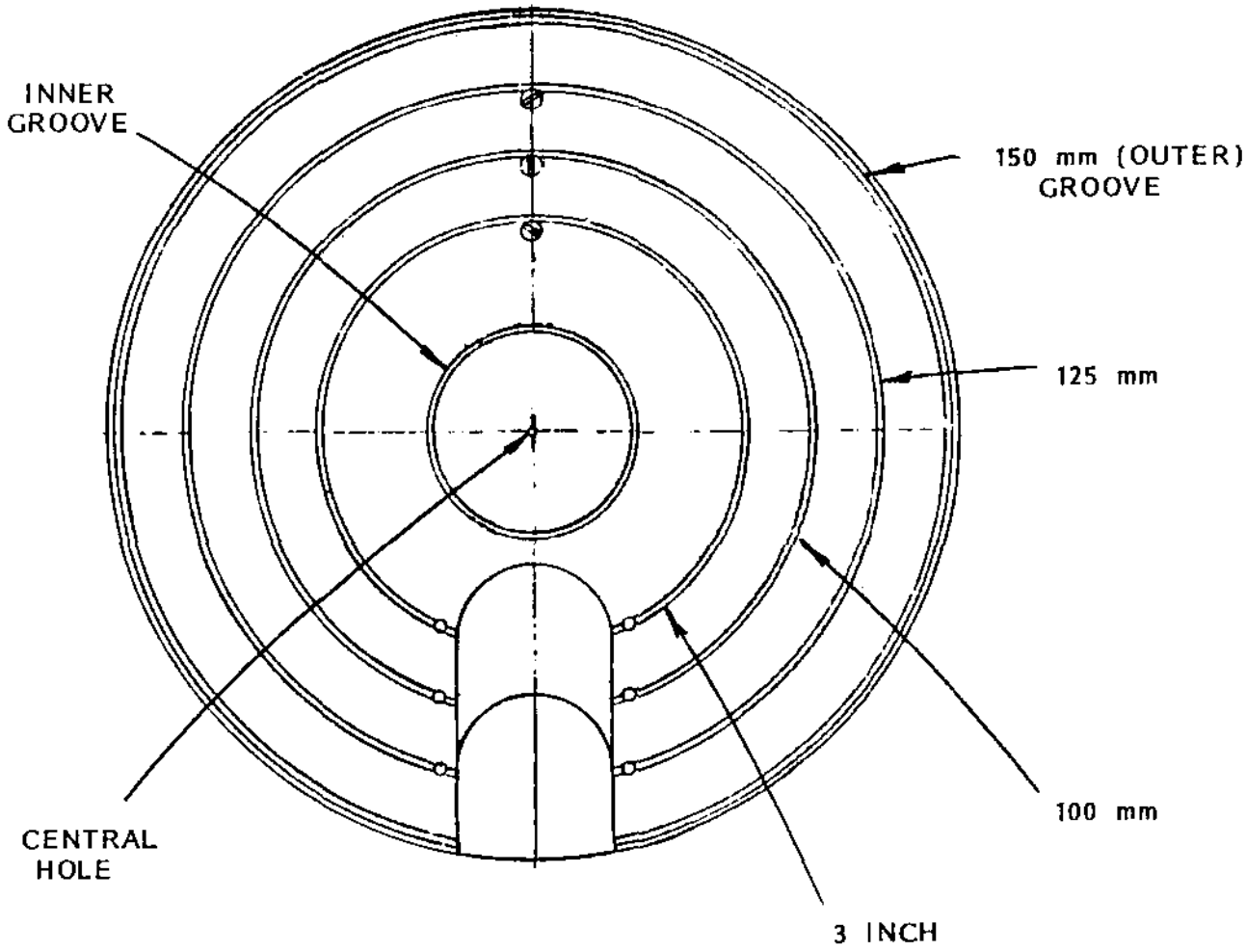


Figure 2 – 3. This is a top view of the 150 mm (almost 6 inches) diameter sample table. See Figure 6 – 1 in the Optional Components section for the top view of the Optional 200 mm diameter table .

1.3 Sample Table Vacuum and Alignment (Continued)

e. Observe the intersection of the two wide diagonal lines and the intersection of the narrow lines. Slowly rotate as needed the **X** and **Y** plane tilt adjustment controls to center the diagonals precisely on the crosshairs intersection. This makes corrections for the sample surface out – of – flatness condition.

NOTE: The width / height of the intersection of the diagonals is four arc minutes. This may be used as a reference in determining the approximate tilt adjustment needed.

f. Using the adjustment wheel under the rear of the table, raise or lower the table to obtain the maximum reading on the **LED** meter. A clockwise rotation of the wheel raises the table.

g. If the reading from step **e** overshoots the **LED** meter upper limit, turn the analyzer drum to lower the gain. Then readjust the table slightly for a maximum reading. Repeat the adjustment of the drum and table vertically as needed for a maximum reading within the range of the **LED** meter.

h. Return to steps **c** through **g** as often as needed until each adjustment is correct.

i. Tighten the sample table clamp screw.

j. See the standard single – point program instructions (such as **STD**) in the Standard Programs sections for the loading instructions, and use the **Film** program or subprogram. Proceed to make a measurement.

k. Compare the thickness data measurement with previously acquired sample thickness data. The compared data should be within **± 3Å** (**± .3 nm**).

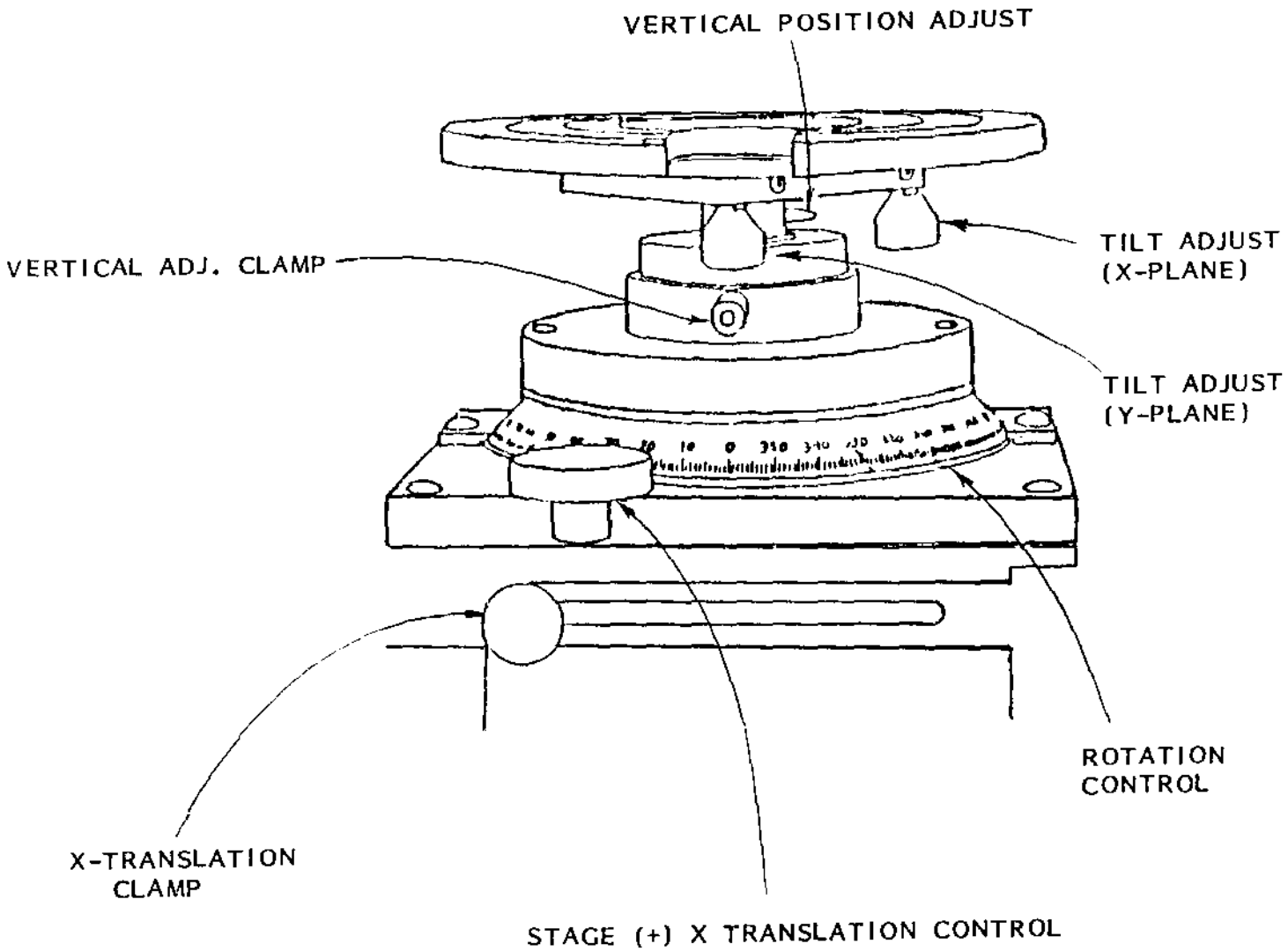


Figure 2 – 4. This is the L116C Sample Stage and Table .

2.0 MEASUREMENT PROCEDURE

Place the sample wafer on the sample table, load the program software into the computer, and initiate the measurements. Once the measurements are started, you press the keys as the screen and instructions request, then measurements are automatic.

Some measurements can be made after a **15 - minute** ellipsometer warmup, the stability of the laser improves after a few hours, which is better for important measurements. If the ellipsometer is in use several times a day, the laser should operate continuously.

WARNING

To avoid the hazard of laser beam dispersion, the beam attenuator must be **closed** while you adjust the polarizer or analyzer arm, or when the two arms are not at the same angle of incidence.

2.1 Standard and Optional Single – Point Measurement Programs

Valid measurements are dependent upon the selection of a program applicable to the sample being measured, and correct interaction by the user with the computer. The standard programs supplied with the ellipsometer are in the Standard Programs section. The optional programs available by special order are identified in the Optional Programs section.

Ideally, the table need not be vertically readjusted between measurements on a series of samples, if all samples in a given lot are plane – parallel, about equal in sample thickness, and no dust particles or other foreign matter are deposited on the surface of the table.

2.2 Automatic Motor Turnoff

An automatic turnoff of the rotating analyzer motor is provided to prolong its life. The motor will automatically turn **off** about five minutes after the last measurement.

Characteristics

1. If the ellipsometer is **on** with the computer **off** and the mode switch is set to **A**, the analyzer drum will rotate once and stop.

2. If both the ellipsometer and the computer are **on** and the mode switch is set to **A**, the analyzer drum will rotate for five minutes before auto turn **off**.

3. When stopped, the motor will automatically turn **on** when a measurement is initiated, and successive measurements will extend the five – minute interval.

2.3 Loading Programs

a. Load the program software into the computer. The loading instructions are in the " Installation " section. Use the Film Program or Film Subprogram of the " Standard Programs " section.

b. Place sample under test on the table, and proceed with the measurements.

2.4 Placement of the Sample

a. Turn **on** the vacuum pump if it is connected. Remove the tiny plugs in the grooves in the stage that will be under the sample. Reinstall any plug that will be under the edge of the sample.

b. Place the sample under test on the stage, and raise or lower the polarizer – analyzer module as needed. (Refer to Subsection 1.3, " Sample Table Vacuum and Alignment ", steps **a** through **k**.)

c. Set the Mode Switch to **A**. The analyzer drum should rotate.

d. Proceed with the measurements by initiating data entry according to the desired program in Section 3 or 4.

At the completion of the measurement sequence, set the Mode Switch to **AS**; and remove the sample from stage. Put on the next sample, and align the arms, as needed, with the knob on the top of the ellipsometer. Set the Mode Switch to **A**, and proceed with the measurements of the next sample (with the analyzer drum rotation).

3.0 CLEANING AND LUBRICATION

These maintenance instructions are operator – level procedures for routine servicing. See the Service Section about trouble analysis, and replacement of defective components, which are for qualified service personnel. Instructions are not included for the replacement of any laser or polarizer / analyzer optical or precision electro – mechanical components. Contact **Gaertner Scientific** about the repair or replacement of these items.

3.1 Cleaning

Interior cleaning of the ellipsometer (i.e., the detector and switch assembly, monitor assembly and instrument power supply) should not be needed. These units are designed to keep foreign matter out. When not being used, the ellipsometer should be enclosed by the dust cover supplied with the instrument. Exposed optical surfaces may be cleaned with a camel – hair brush or clean, dry compressed air (not to exceed **5 PSI**). All other external surfaces may be wiped clean using a soft, lint – free cloth. If a solvent is needed, a cloth dampened with wood or isopropyl alcohol is recommended.

3.2 Lubrication

Periodic lubrication is not required.

The L116C Ellipsometer is shipped fully assembled, along with needed items, in a single shipping crate.

- L116C User Manual
- Ellipsometer / Computer Interface Cable
- * GPIO Interface Card (for **IBM PS / 2-25 Series** Computers or Equivalent)
- Software Programs
- Silicon Wafer (Reference Sample)
- Dust Cover

* This component is supplied to customers who have their own computers. But computers that are shipped with the Ellipsometer will have the **GPIO** card already installed.

UNPACKING

Remove the protective wrapping from the Ellipsometer. Remove the lag bolts that secure the hold-down clamps to base of the Ellipsometer. Remove the hold-down clamps. This allows removing the Ellipsometer from the shipping crate base platform.

NOTE: Store the shipping platform, shipping crate components and protective wrapping for use in the event of reshipment to Gaertner for repair.

WHEN PACKING THE ELLIPSOMETER FOR RESHIPMENT TO GAERTNER FOR REPAIR, INCLUDE THE SOFTWARE PROGRAMS AND INTERFACE CABLES (WITH GPIO INTERFACE CARD, IF APPLICABLE). CONTACT GAERTNER FIRST.

CAUTION

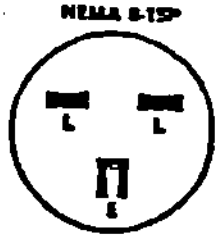
In event of reshipment, precautions must be taken to ensure that (**1**) the polarizer arm is set and clamped at **50°** angle of incidence and (**2**) the analyzer arm is set and clamped at **50°** angle of Incidence prior to packing.
This will prevent a possibility of damage to the helium – neon (**red**) laser and the analyzer module.

Gaertner Ellipsometers are supplied with U.S. plugs (NEMA 5-15P). If it necessary to change the plug, the following guidelines apply:

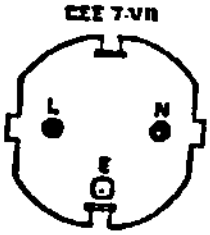
Great Britain, Cyprus, Nigeria, Rhodesia and Singapore

Underwriter's Laboratory approved for the United States, Canada, Japan, Mexico, Philippines and Taiwan

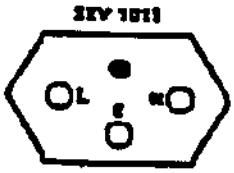
Australia and New Zealand



UL approved for the U.S.



Eastern and Western Europe, Saudi Arabia, and United Arab Republic



Switzerland

Figure 5-1.

NOTE: All plugs are for single-phase power and are viewed (above) from the connector end. The prongs are:

- **L =** Line or active conductor, also called " **live** " or " **hot** ". The insulation is **black**.
- **N =** Neutral or identified conductor. The insulation is **white**.
- **E =** Earth or safety ground. The insulation is **green**.

INSPECTION

Thoroughly inspect the Ellipsometer for shipping damage. If there is damage from transit, notify the carrier.

Verify that a key is installed in keylock switch on the right side of the Sample Monitor Assembly (above the sample table) and is off. Check that a good fuse is in the Ellipsometer.
Verify that all of the applicable items have been included in the shipment.

LOCATION CONSIDERATIONS

The L116C Ellipsometer is designed for use in either a production or laboratory facility under relatively constant room temperature and a relatively dry, dust - free atmosphere. The Ellipsometer requires a clean, level solid work surface sufficient to also accommodate the interfaced computer. The **ac** line voltage must be free of large transients having harmonics in the range from audio frequencies to several megahertz. Do not obstruct the ventilation holes on any of the equipment.

INTERCONNECTIONS

DO NOT plug or unplug any component into or from **ac** power or make connections to other equipment with its power **ON / OFF** switch **ON !**

The **ac** line cable for the Ellipsometer and the laser is on the rear of the instrument and may be

labeled **INPUT POWER**.

CAUTION

Verify that the power switches on all of the components are **OFF** before connecting or disconnecting the interface cabling.

A connection diagram for the **L116C** is shown in Figure 5-2.

Ellipsometer and **Computer** See Figure 5-3 (Ellipsometer Rear View) and Figure 5-4,

IBM PS / 2-25 Computer.

COMPUTER IBM PS / 2-25 AND PRINTER HP THINKJET HP2225C OR EQUIVALENT

Connect the Centronics Interface Cable (**7108-E239T**) at the parallel receptable at the rear of the computer and the rear of the **ThinkJet** printer.

See Figure 5-3 (**IBM PS / 2-25**).

Hand tighten the connector thumb screws.

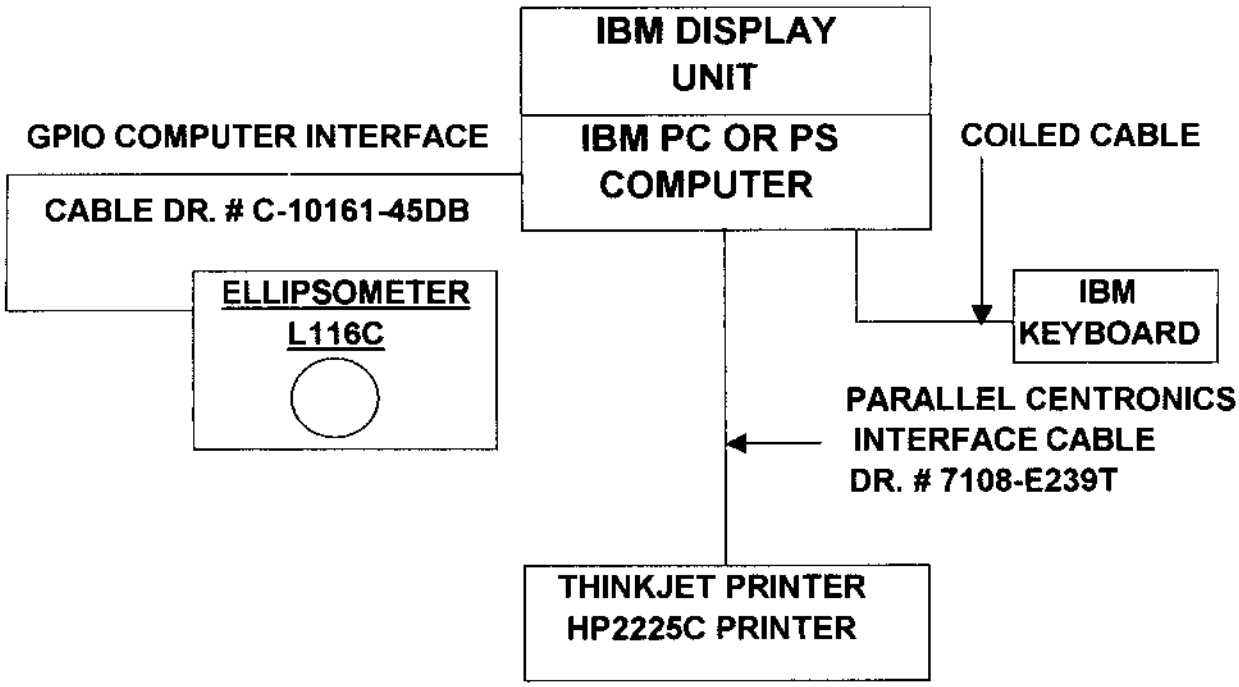


Figure 5-2. This is the Ellipsometer L116C Interconnection Diagram. The computer that Gaertner will supply with the L116C is the IBM PS/ 2-25.

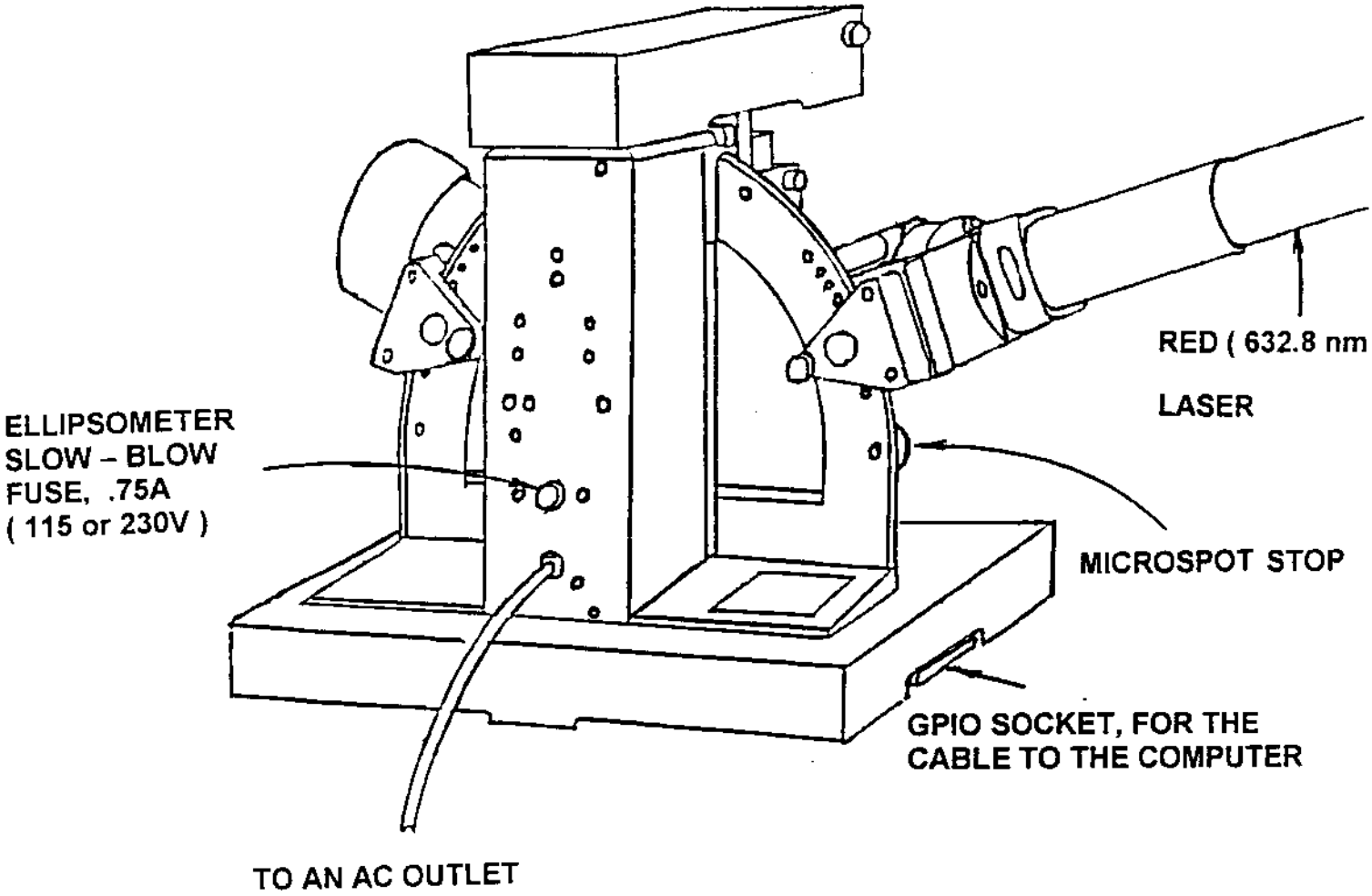


Figure 5-3. This is the rear and left view of the L116C Ellipsometer with the 6" Diameter Table and the 632.8nm helium-neon laser.

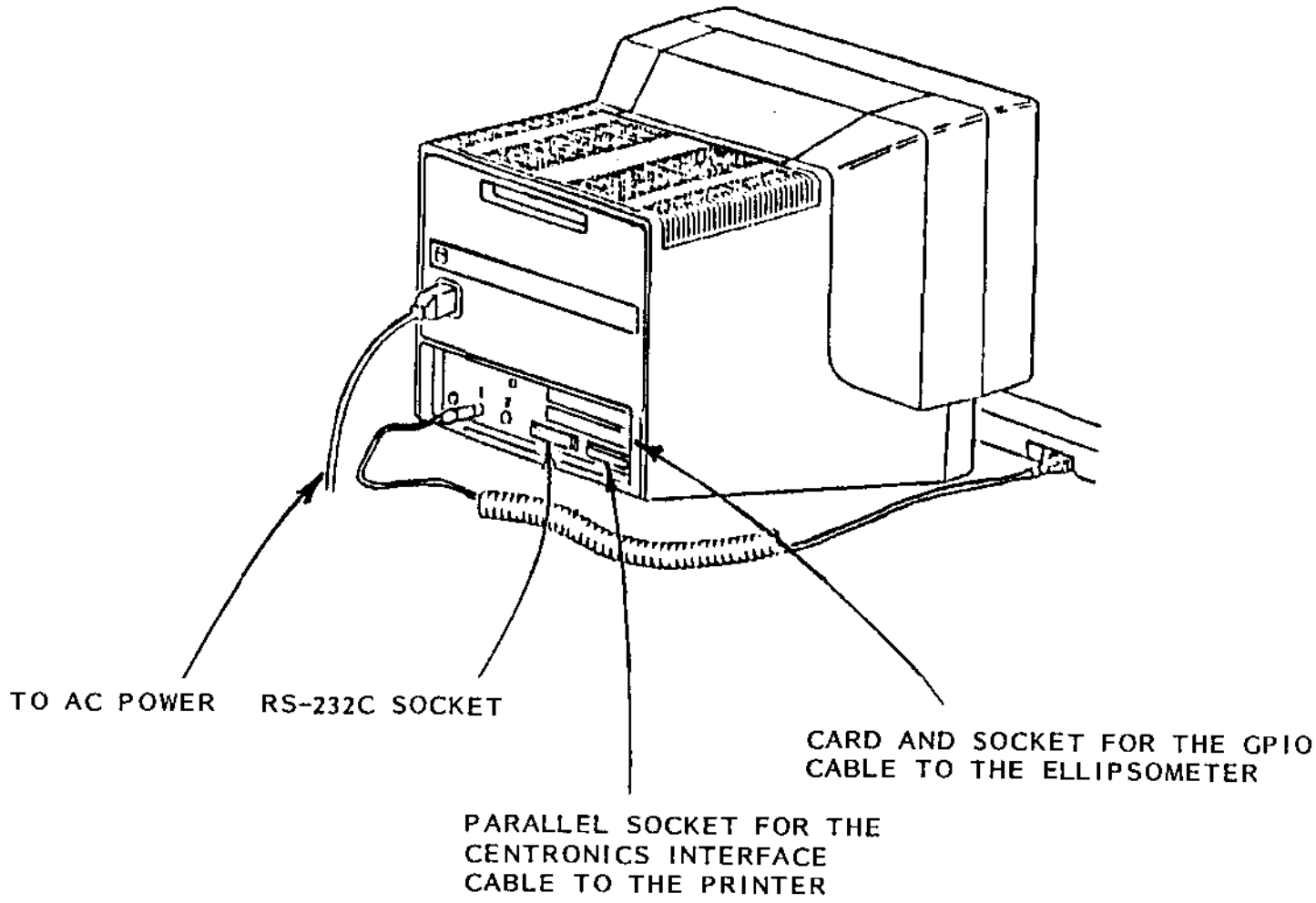

TO AC POWER
RS-232C SOCKET
CARD AND SOCKET FOR THE GPIO CABLE TO THE ELLIPSOMETER
PARALLEL SOCKET FOR THE CENTRONICS INTERFACE CABLE TO THE PRINTER

Figure 5-4. This is the IBM PS/2-25 computer and its connections, which is generally used with the L116C Ellipsometer and is the one that Gaertner will supply with that Ellipsometer.

SOFTWARE INSTALLATION AND LOADING

NOTE: Wherever this instruction tells you to type in some specific characters, the characters are in boldface and just after " **TYPE** ". Type in the Characters, and press **ENTER**.

Software Installation and Loading.

The Ellipsometer should be on **15 minutes** before using, but **30 minutes** would be better. Turn **ON** the computer display unit and the printer. Insert the program disc into drive **A**, and turn **ON** the computer. The program should boot automatically. If **DOS** is already loaded, place the program disc in the appropriate disc drive, i.e., **1.2M** drive for programs using **IBM PC AT** and **720k** for **PS / 2** or **360k** drive for programs using **IBM PC** or **IBM PC XT**.
For example, if " **A:** " or " **A>**" is displayed on the screen, drive **A** is the default drive (the drive that the computer selects when the computer is turned **ON**). If the program disc is compatible with drive **A** and inserted into drive **A**, then just type **AUTOST** and press **ENTER**. The program will load and start running.

COMPUTER CIRCUIT BOARD INSTALLATION

INTRODUCTION

NOTE: If the computer was supplied by Gaertner along with the **L116C**, then the circuit boards mentioned here were already installed. Ignore this and the next three pages.
These instructions are for installing the **GPIO Interface Card** and **Cable** assembly into the **IBM** and **IBM** compatible computers for use with the **L116C** Ellipsometer. The computer **Interface Card DIP** switch settings and installations are described here.

GPIO DIP SWITCH ADJUSTMENT

The **GPIO** Interface Card is shown in **Figure 5-5**. This card has three sets of **DIP** switches. The smallest set of **DIP** switches, close to the card connector on the far right, has six or ten tiny slide switches. On the six-switch unit, switches **1** and **2** are **OFF** and the other four slide switches are **ON**. On the ten-switch unit, switches **5** and **6** are **OFF** and the other eight switches are **ON**.

LASER RETARDATION

The other two sets of **DIP** switches are on a small board near the middle of the card. Each of these two larger sets of **DIP** switches has **12** tiny rocker switches, one unit (of **12** switches) is for the infrared / blue laser and one for the red. The rocker switch settings are different for each laser. The settings of the infrared / blue laser switches should be closed if the instrument has only a red laser.

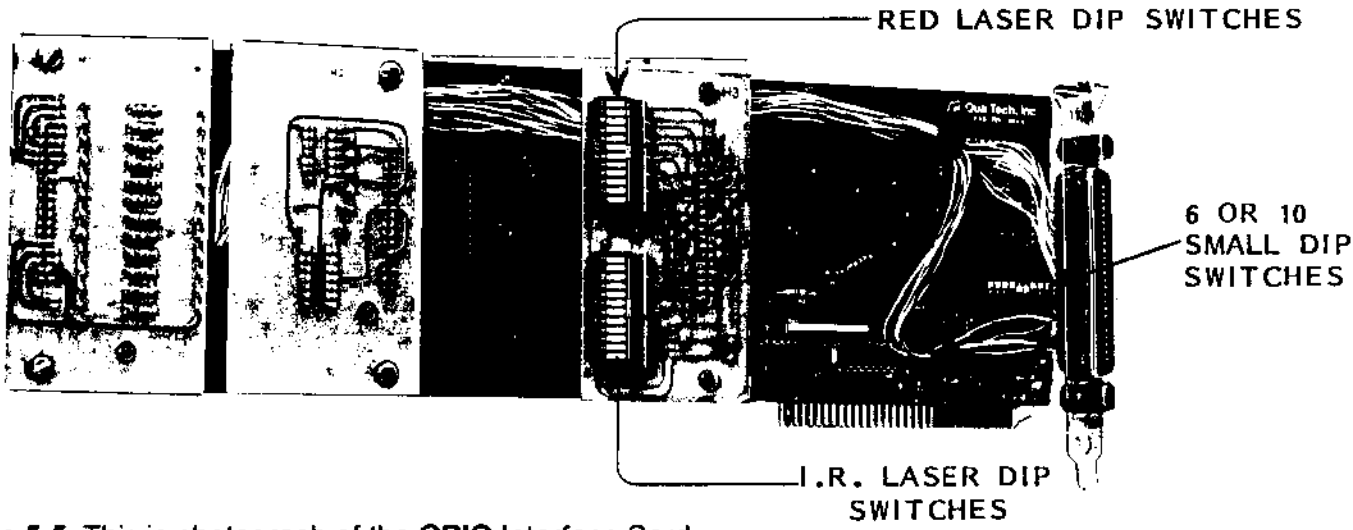


Figure 5-5. This is photograph of the **GPIO** Interface Card.

LASER RETARDATION (Continued)

Each set of **12** small **DIP** rocker switches is divided into **3** groups of **4** switches. Each rocker switch is assigned a weight (**1**, **2**, **4** or **8**) and a logic (switch setting: **" ON " / open =1; " OFF " / closed = 0**). The logic multiplied by the weight and added to the products (weighted logics) of the other switches in a group determines a **" place "** digit. The laser retardation value is obtained by combining the **3 " place "** digits. Rocker switches **1 to 4** determine the **" tens place"**; **5** to **8** determine the **" units place "**; and **9** to **12** determine the **" decimal place "**. **(In** the case of **3-Wavelength** Ellipsometers, the **I.R.** retardation value will be in the software program.)

RED LASER RETARDATION (See **Figure 5-6**)

Assume the red laser retardation is **96.6**. Switch **1** is open; its logic, **1**, multiplied by its weight, **8**, gives a weighted logic of **8**. Switch **4** is open (logic **1**, weight **1**); weighted logic is **1**. Switches **2** and **3** are closed (logic **0**); weighted logic of each is **0**. The total weighted logic of switches **1** to **4** is **8+0+0+1=9** (**" tens place "**). Switches **5** and **8** are closed; weighted logic **0**. Switch **6** (weight **4**) is open; weighted logic is **4**. Switch **7** (weight **2**) is open; weighted logic is **2**. The total weighted logic of switches **5** to **8** is **6** (**" units place "**). Switches **9** and **12** are closed; weighted logic is **0**. Switch **10** (weight **4**) is open; weighted logic is **4**. Switch **11** (weight **2**) is open; weighted logic is **2**. The total weighted logic of switches **9** to **12** is **6** (**" decimal place "**).

1523nm I.R. BLUE LASER RETARDATION (See **Figure 5 -6**)

Assume the **I.R.** / blue retardation is **103.9**. Switches **1** (weight **8**) and **3** (weight **2**) are open; switches **2** and **4** are closed. Total weighted logic is **10** (**" tens place "**). Switches **5** and **6** are closed; switches **7** (weight **2**) and **8** (weight **1**) are open. Total weighted logic is **3** (**" units place "**). Switches **9** (weight **8**) and **12** (weight **1**) are open; switches **10** and **11** are closed. Total weighted logic is **9** (**" decimal place "**).

830nm I.R. / BLUE LASER RETARDATION

For the diode (infrared) laser, the value of retardation will be lower (around **70**).

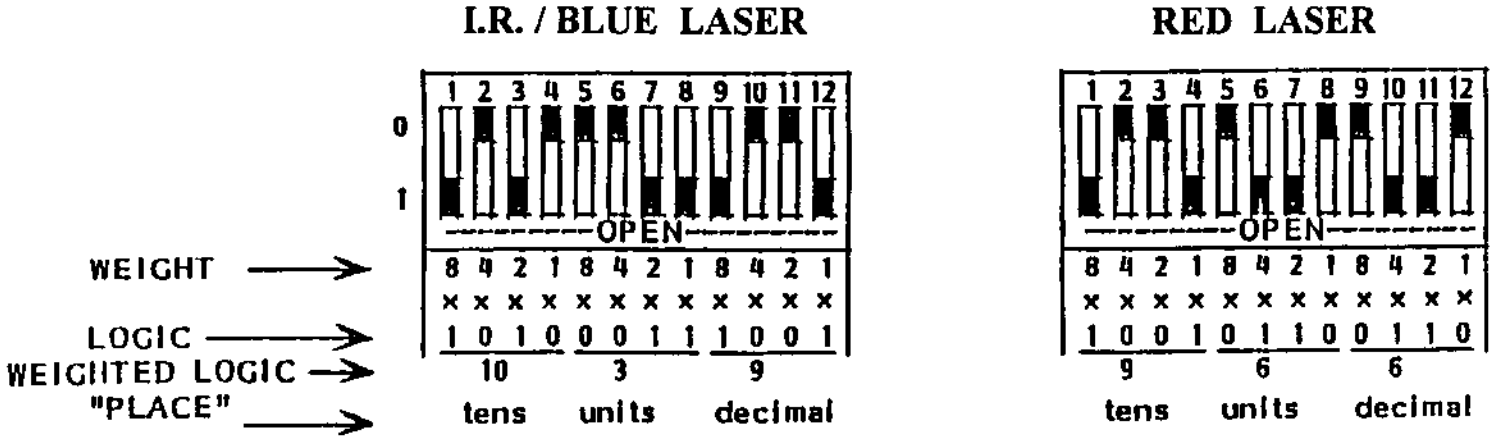

I.R. / BLUE LASER
RED LASER
1 2 3 4 5 6 7 8 9 10 11 12
0
1
OPEN
WEIGHT
8 4 2 1 8 4 2 1 8 4 2 1
LOGIC
1 0 1 0 0 0 1 1 1 0 0 1
WEIGHTED LOGIC
10 3 9
"PLACE"
tens units decimal
1 2 3 4 5 6 7 8 9 10 11 12
OPEN
8 4 2 1 8 4 2 1 8 4 2 1
1 0 0 1 0 1 1 0 0 1 1 0
9 6 6
tens units decimal

Figure 5-6

IBM PS / 2-25

This computer is the one most often used with the **L116C** Ellipsometer. To install the **GPIO** Interface Card, refer to " **IBM Operations and Starter Diskette** ", first edition (**June 1987**). **Section 2** is " **Installing Your Options** ". The cover is shown removed on pages **2-3** and **2-4**. The circuit board installation is shown on pages **2-13** and **2-14**, and the **GPIO** Interface card should be installed in the lower expansion slot. The cover is reinstalled according to pages **2-16** and **2-17**.

IBM PS / 2-25 286

The differences between this computer and the one in the paragraph above include the **VGA** Plus circuitry and a hard disc in this computer. The rear panel socket arrangements are virtually the same. The **GPIO** card should go in the lower position. See **Section 3** (pages **3-18** to **3-23**) of the Computer Manual, " **IBM Personal System / 2 Model 25 286 Guide to Operations** " (**1990**), for the card installation.

IBM PS / 2-30

" **IBM Personal System / 2 Model 30 Guide to Operations** " booklet (copyright **1987**). **Section 3** is " **Installing Your Options** ". The cover removal instructions are on pages **3-3** and **3-4**. The adapter (Interface Card) Instructions are on pages **3-6** to **3-8**. The **GPIO** Interface Card (with the three **DIP** switches) is mounted in the middle position. The cover is reinstalled according to page **3-9**.

IBM PS / 2-30 286

This computer is basically the same a the **IBM PS / 2-30**. Refer to computer manual, " **IBM Personal System / 2 Model 30 286 Guide to Operations** " (**1988**), concerning card installation.

IBM PC AT

The Interface Cards are installed vertically according to the **IBM PC AT** " **Installation and Setup** " manual (copyright **1984**). **Section 2** describes the cover removal procedure. **Section 3** is the " **Internal Option Installation** ". Page **3-8** shows the eight vertical positions available. The **GPIO** Interface Card can be installed in any of these eight positions. **Section 4** is for the cover installation.

L116C ELLIPSOMETER

SAMPLE STAGES

Hand Positioning Stages

L116HXY6 - This stage accommodates **6-inch** samples and enables the sample table to be moved by hand in **X**, **Y** and **θ** directions to facilitate at any desired point on the sample surface. The **X** and **Y** coordinates translation facilitates measurement on a rectangular or grid pattern; **zero** (**0**) to **2** inch left - to – right translation (**X** direction) , **1- inch** in the - **Y** direction from center, and **½- inch** in the **+Y** direction. Total rotational travel (**θ** direction) is **0°** to **360°**. If the white plastic retainers are removed from the table, translation in the **+Y** direction is increased to **1-inch**.

L116HXY5 - This stage is identical to the **L116HXY6** stage except that the table will allow measurements on samples no greater than **5** inches in diameter. Front-to-back translation (**Y** direction) is **± 1- inch** from center.

Micrometer Positioning Stages

L116MXY6 - This stage is identical to the **L116HXY6** stage except micrometer thimbles are added to allow fine motion translation in the **X** and **Y** directions to facilitate positioning within rectangular scribe lines. One division on the thimble equals **0. 001- inch**. This stage is especially useful with the **Microspot Optics Option L116MS** accessory.

L116MXY5 - This stage is identical to the **L116MXY6** stage except will allow measurements on samples no greater than **5-inches** in diameter.

FINE MOTION HEIGHT ADJUSTMENT L117FM This feature may be added to any type of sample stage, and comprises a rotatable inclined plane acting through a transfer plate and the coarse height adjustment to raise or lower the table **0.010 inch** maximum (from mid-position reference) after setting of the standard height adjustment. One half turn of the adjustment knob equals 0. 010 inch. The adjustment knob is at mid-position when the center line of the reference hole on the knob is coincident with the centerline of the table clamp screw. Clockwise rotation of the adjustment knob raises the table; counterclockwise rotation of the adjustment knob lowers the table.

MICROSPOT OPTICS L116CMS (Gaertner Installed)

This option has a projector optic that reduces the normal **1 mm** diameter beam at the sample surface down to **0.015 mm** (to measure very small areas) and a receiver optic (for added efficiency). See the table in Subsection 1.0 (**Specifications**) in the " **Description** " Section of this user manual.

NOTE: The table in Subsection 1.0 (**Specifications**) shows the dimensions of the laser beam on the sample with and without the **Microspot Optics** at different angles of incidence, ϕ.

INTERFACE LRS232

This option enables the user to send or receive serial data via an interface with **RS-232C** compatible equipment such as a large-scale (host) computer, data terminal and modems. Includes interface cable, modified software and program User Instructions.
Contact **Gaertner** for details on specific data communication specifications.

VIDEO MONITOR L115VM

This option allows the ease of monitoring a wafer pattern display on a **CRT** screen in addition to the standard viewing microscope. An **M / T** switch is usually mounted on the front of the Sample Monitor Assembly when a video monitor is included with an ellipsometer.

WAFER HANDLER L116WH

Model **L116WH** Wafer Handler permits unattended automatic measurement of up to **25** wafers from a cassette. The randon- access indexer on the Wafer Handler is ultra clean with the mechanism fully contained within the housing so that there are no moving parts near the wafer. The " frog-leg " type of motion of the arm is simple, clean and gentle.

200mm (7.9 inches diameter) SAMPLE TABLE

This larger table is for **3"** (**76 mm**), **100 mm**, **125 mm**, **150 mm** and **200 mm** wafers for film measurements. See Figure 6-1 for a top view of this table.

NOTE: If an ellipsometer has a **200 mm** diameter table **and** the **Microspot Optics**, it is not possible to move this table out of the two arms so that they can be set at a **90°** incidence angle; thus ignore any instructions that call for setting the arms at **90°**.

FINE MOTION HEIGHT COMPONENTS

1.0 Description

This feature may be added to any type of sample table and consists of a rotatable inclined plane acting through a transfer plate and the standard height (vertical position) adjustment to raise or lower the table **0.254mm (0.010 inch)** maximum (from the mid – position reference) after setting the standard vertical position. One half turn of the knob moves the table **0.010** inch. The knob is at the midposition when the center line of the reference hole on the knob is at the centerline of the table clamp screw.
A clockwise rotation of the knob raises the table (**CCW** lowers the table).

2.0 Using the Adjustment (See Figure 6-2.1, page 6-2.2)

- Loosen the table clamp screw.
- Set the reference hole at mid – position.
- Use the coarse height adjustment to raise or lower the sample table to the approximate height required.
- Rotate the fine motion up to a one - half turn in either direction to obtain the required height.
- Tighten the table clamp screw.

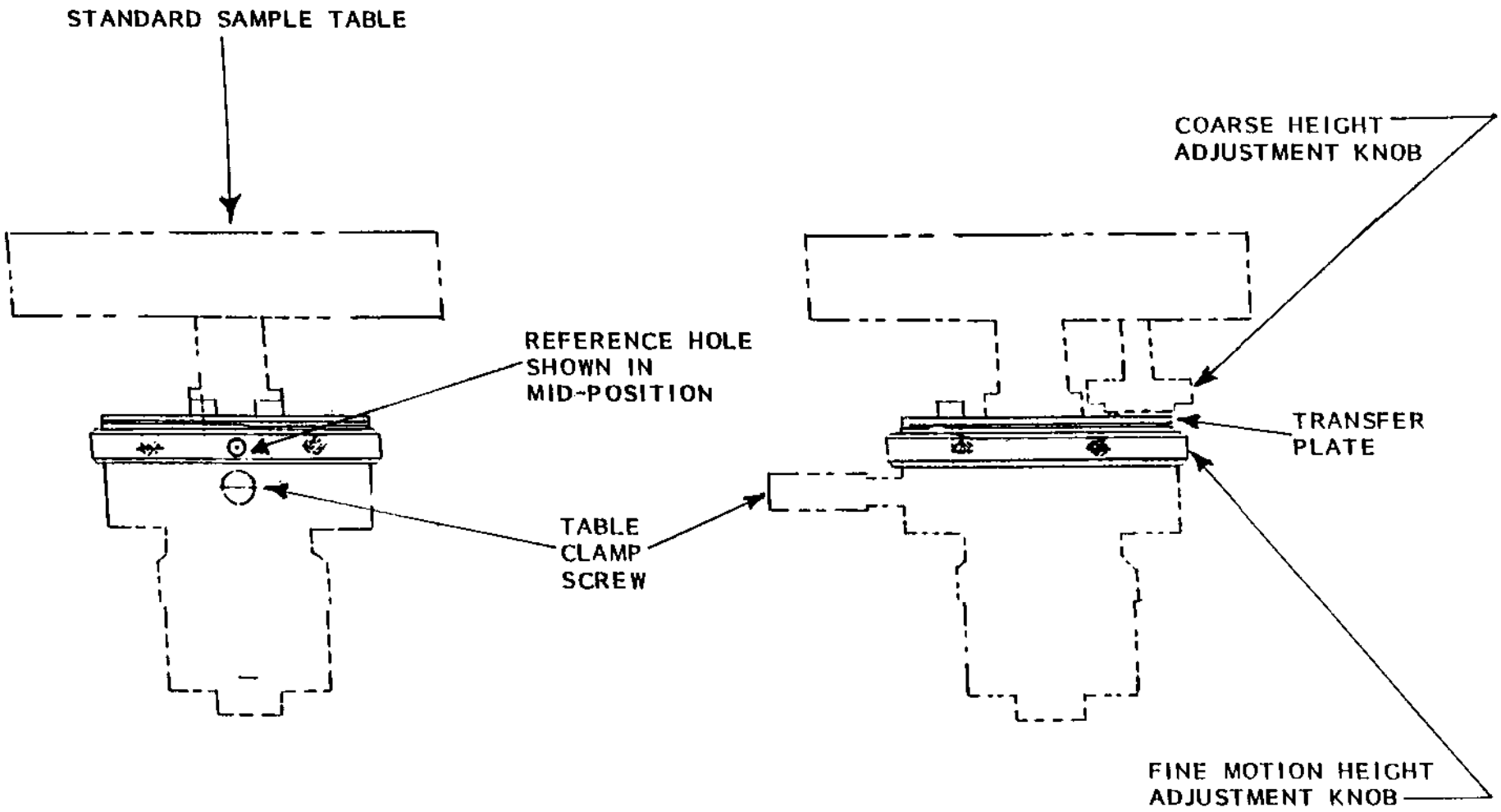


Figure 6-2.1 Front and side views of the L117FM Fine Motion Height Adjustment Component.

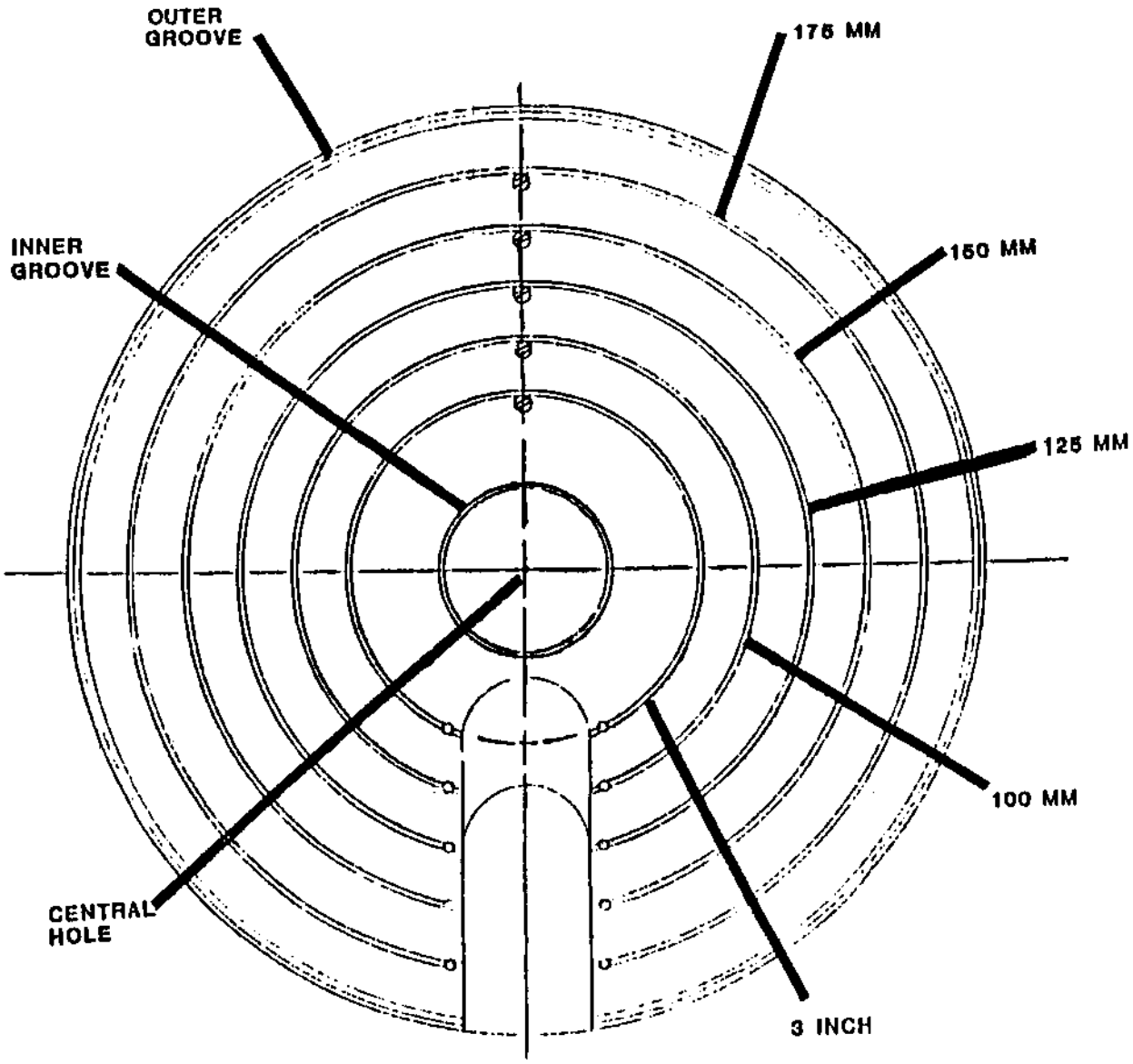


Figure 6-1. This is a top view of the 200mm (7.9 inches) diameter sample table.

1.8 TROUBLE ANALYSIS

This ellipsometer should have long-life, trouble-free operation. In the event of a malfunction, symptoms are readily traceable by the use of built-in test jacks and intermediate check points. This should be done by qualified service personnel. Fault isolation involves trouble-shooting to identify the cause of failure only to a component or assembly readily removable for further fault isolation and repair or replacement. During automatic operation, a malfunction is usually shown by no measurement data, inconsistent measurements, or even operator-induced errors.

1.1 Measurement System

During automatic operation, the analyzer drum (with the prism inside) rotates at a speed regulated by a closed-loop, motor-speed control system. (See Figure 7-1, next page.) Motor pulses originating at discrete intervals from an encoder are amplified and applied to the input of a motor speed controller. Within the encoder, the pulses are derived from a phototransistor circuit activated by a light emitting diode (**LED**). Actual motor speed is determined by frequency-to-voltage conversion of the input. This voltage is compared to an externally preset reference voltage. The result of the comparison controls the drive voltage to the motor, keeping the motor speed constant. A " **stall timer** " prevents motor burn-out in the event of a mechanical stall.

Intensity readings of the reflected light, as sensed by the photodetector, are taken at **5°** intervals during one revolution of the analyzer prism, beginning at **0°** and ending at **355°**. The readings are taken in the dual mode, sequenced under program control via input from the computer. One set of readings (**72 data points**) is taken with the **+90°** compensator in the optical path. The other set of readings is taken with the compensator withdrawn from the optical path.

The output current of the photodetector is converted to an analog voltage varying sinusoidally in amplitude and proportional to the intensity of the reflected light. The analog output is amplified and applied to the input of an analog-to-digital (**A / D**) converter. A zero offset adjustment in the photodetector circuit is factory preset to ensure optimum accuracy in measurement, especially for very thin films. After each set of readings, the maximum analog output is checked by the computer software. If measurement accuracy can be improved by changing the gain, the **CTL 1** input logic will switch the gain range and a repeat set of readings will be taken. A logic " **0** " closes the switch, decreasing the gain; a logic " **1** " opens the switch, increasing the gain.

A reference pulse from an optical switch and between **356°** and **359°** of the analyzer drum rotation, initiates the measurement cycle. The reference pulse is derived from a phototransistor circuit activated by a **LED**. If a peripheral control (**PCTL**) signal from the computer is present during the period of the reference pulse, indicating that the computer is ready to accept a reading, a timer is activated (turned on).

(section 1.1 continued on page 7-4)

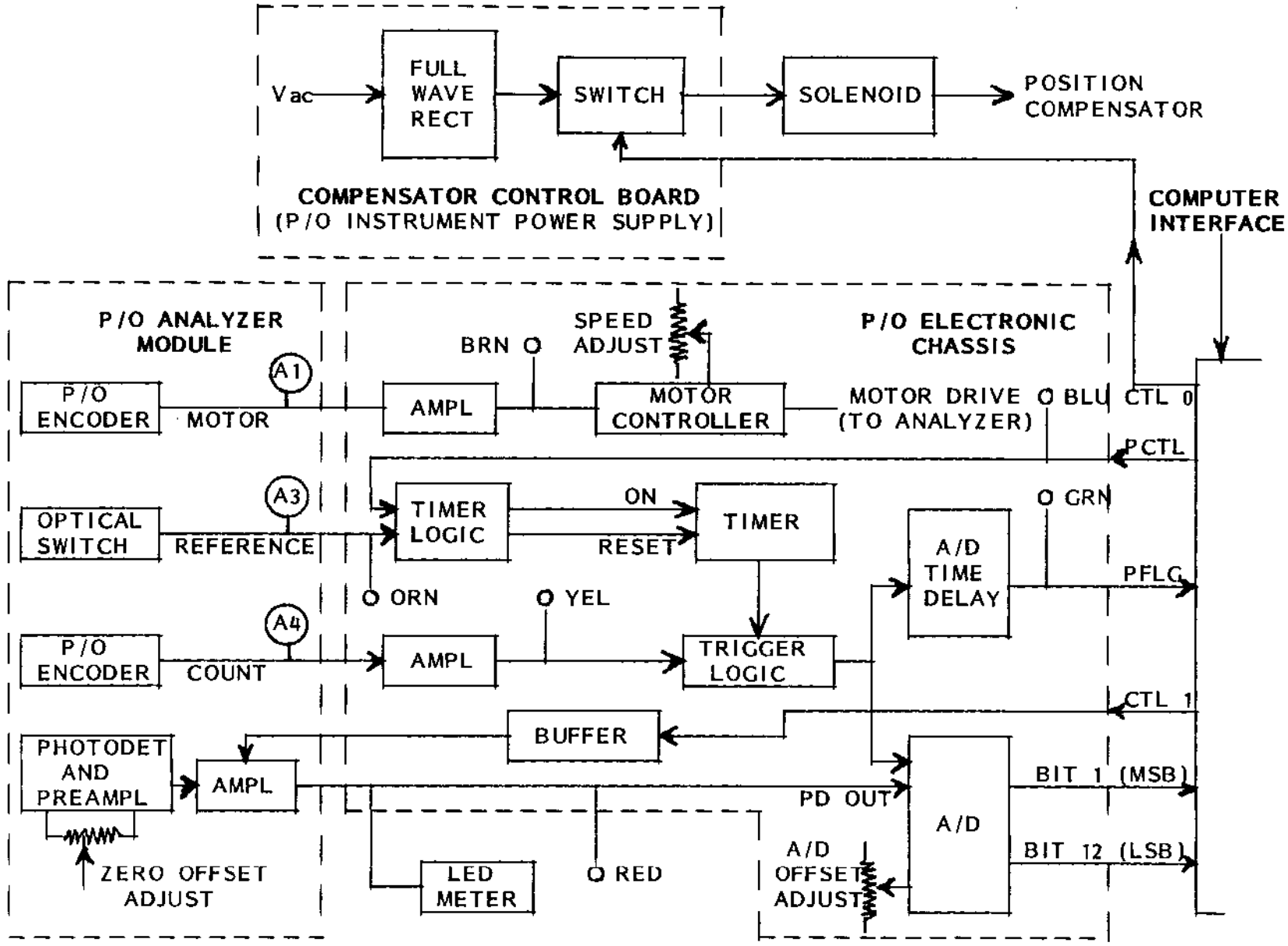
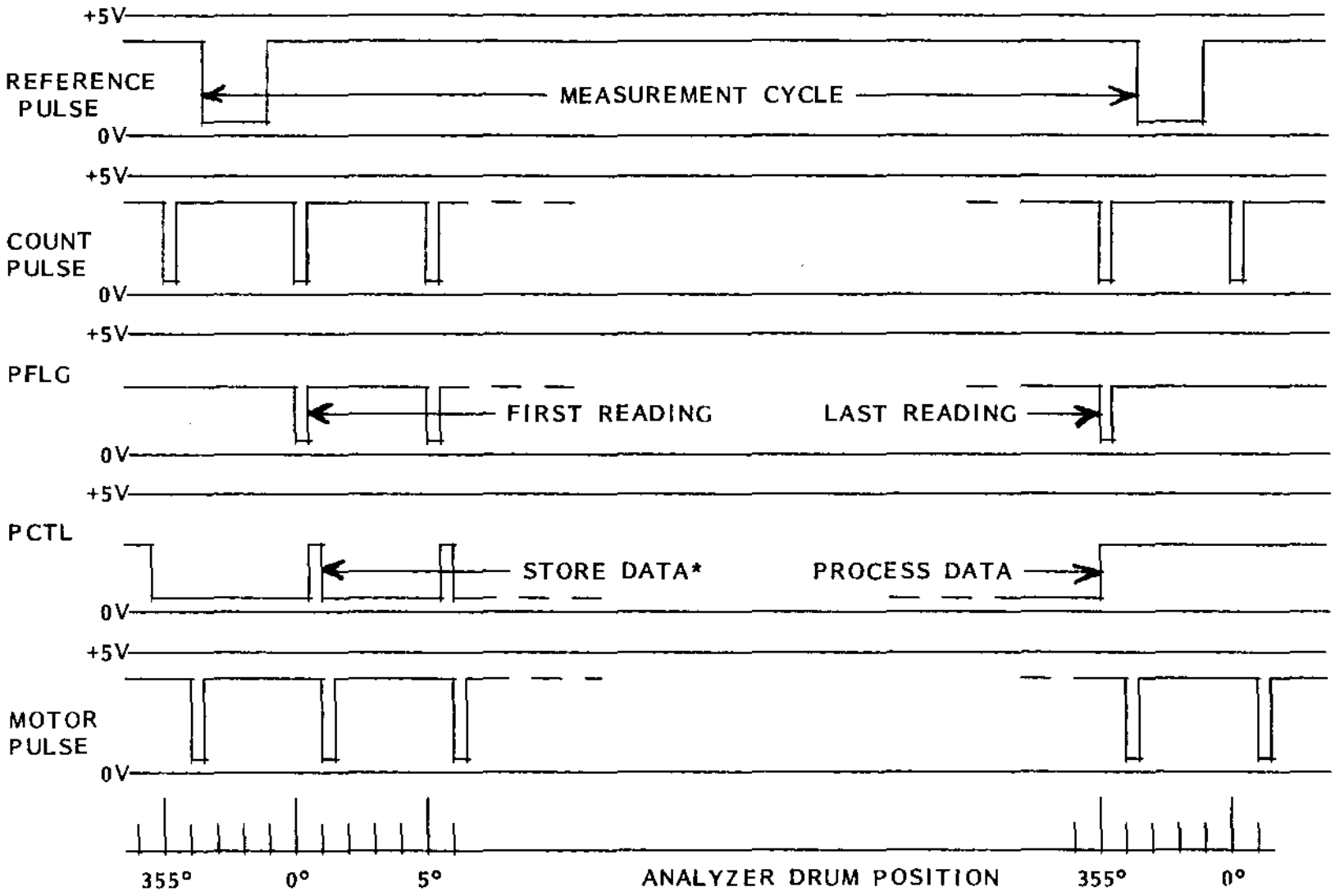


Figure 7-1. This is the Measurement System Functional Diagram.



* The STORE DATA pulses will not appear in some makes of computers.

Figure 7-2. These are typical pulses during the Measurement Cycle.

1.1 Measurement System (Continued)

For the first set of readings count pulses, starting at the **0°** position of the analyzer rotation, trigger the **A / D** converter to accept the photodetector analog output. The count pulse is derived from a phototransistor circuit activated by a **LED** in the encoder, in the same manner as previously described for the motor pulse. About **30 microseconds** later, allowing time for **A / D** conversion, a peripheral flag (**PFLG**) signal Is sent to the computer. Indicating that a set of readings is ready for the computer.

The reading, in **12-bit** digital format, is then accepted by the computer. The cycle is repeated for each subsequent count pulse, occurring every **5°**, until **72** readings have been processed and stored by the computer. The next reference pulse resets the timer and terminates the measurement cycle.

Under program control, the compensator position is changed and a second set of **72** readings is taken in the same manner as previously described. An external PD zero offset adjust is factory preset to set zero light level of the **A / D** conversion such that measurements are insensitive to changes in gain of the photodetector output, ensuring minimum distortion.

A solenoid-operated slide places the **+90°** compensator in the laser-light path and then removes it from the light. When a **" control zero "** (**CTL 0**) signal from the computer is applied to a switching transistor circuit on the compensator control board, the solenoid Is energized to insert the compensator in the optical path. When the **CTL 0** signal is at logic **0**, the solenoid is de-energized to remove the **+90°** compensator from the optical path.

1.2 Test Jacks

Seven color-coded test jacks (including a common ground) are on the right side of the electronic chassis at the base of the ellipsometer. These test jacks are useful in trouble-shooting to identify symptoms of malfunction and to isolate faults without first requiring access to the interior of the ellipsometer. These test points (with a trimpot on each end) are identified as follows:

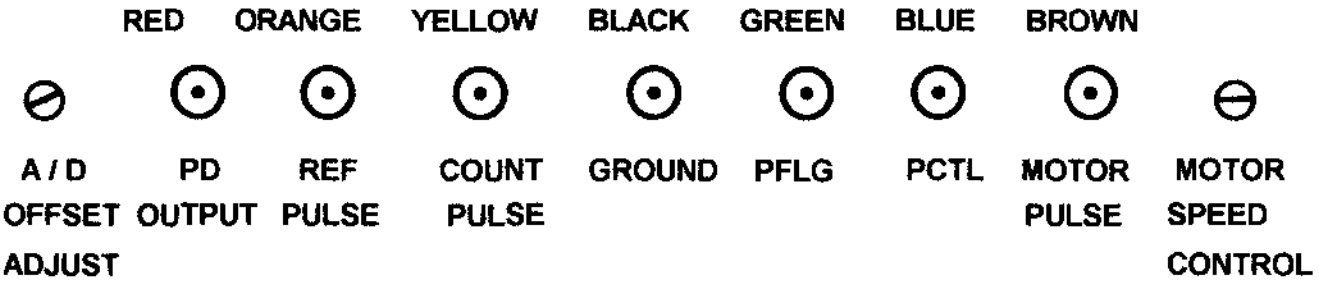


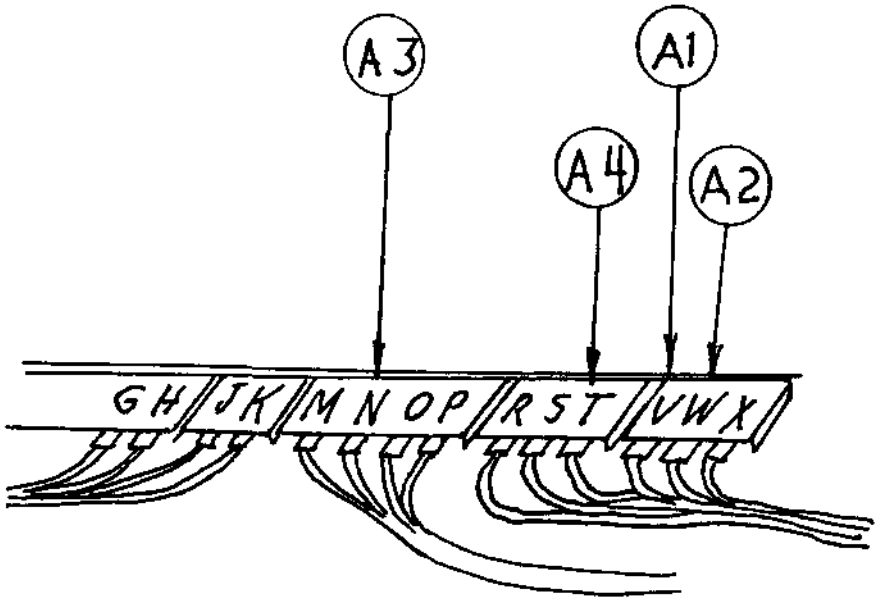
Figure 7-3. These are seven test jacks and two trimpots on the right side of the ellipsometer base.

1.2 **Test Jacks** (Continued)

NOTE: Logic **1** is less than one (**1**) volt. Logic **0** for reference, count and motor pulses is greater than **4.0 volts**. Logic **0** for **PCTL** and **PFLG** is greater than **3.0 volts**.

- **PD Output** The photodetector / amplifier output is sinusoidal with an amplitude of up to 10V, peak to peak and a period of **180°** of the analyzer drum rotation.
- **Ref Pulse** This pulse occurs between **356°** and **359°** of the analyzer drum rotation. These pulses are always present as long as the drum is rotating (in automatic, with the Mode switch at **A**). Logic **1** starts the automatic measurement cycle if the logic **1 PCTL** (peripheral control) signal is also sent by the computer.
- **Count Pulse** These pulses occur within ½ ° of the analyzer drum position readings evenly divisible by five, between **0°** and **355°** of the analyzer drum rotation. Logic **1** triggers an **A / D** converter to accept the photodetector output during the measuring cycle.
- **Ground** This is the common ground for any measurement at each test jack and check point.
- **PFLG** These pulses are the logic **1** peripheral flag signals to the computer (only during the measurement cycle) and occur about **30** microseconds after the leading edge of each count pulse. They indicate that a reading is ready for the computer. The pulses end at trailing edge of count pulse.
- **PCTL** These are the logic **1** peripheral control pulses from the computer (only during the measurement cycle). They signal the system that the computer is ready to accept a reading. When the pulses are coincident with the reference (**ref**) pulse, a timer is activated for the duration of the measurement cycle.
- **Motor Pulse** These pulses occur ½ ° to **1**- ½ ° after each count pulse.

Typical outputs at these test jacks (except the **PD** output) are shown in Figure 7-2. The use of an oscilloscope with a high -persistancy screen or a storage cathode-ray tube would display the waveforms clearer because of the slow sweep across the screen when the reference pulses are observed. An oscilloscope with two or more traces is needed to compare the pulses. It may be necessary to use the oscilloscope's external trigger on the reference pulse for a more stable pulse display.



Fiqure 7-4. These are the four Check Points (A1 to A4) in Figure 7-1 (which does not show A2). In order to observe the waveform or measure the voltage, carefully pull out the appropriate connector just enough to carefully insert a sharp probe (with the common probe at the black test jack).

1.3 Troubleshooting

Table 7-1, starting on the next page, lists the symptoms of malfunction, possible causes and corresponding actions relative to fault isolation. The symptoms are listed in a sequence generally reflecting the operating procedure, i.e., premeasurement setup and measurement procedure. As a troubleshooting guide, the listing assumes all **dc** power supplies are operative and no discontinuity in wiring. Certain fault isolation actions are keyed to intermediate check points **A1** to **A4**. The check points are shown in Figures 7-1 and 7-4 and are just below the photodetector board in the detector/switch assembly section of the analyzer module. Remove the detector/switch assembly cover for access to these four check points.

Table 7-1. TROUBLESHOOTING GUIDE

SYMPTOM	POSSIBLE CAUSE	FAULT ISOLATION
No power to the ellipsometer (Key switch at **ON**)	No line voltage	Verify that the ellipsometer power cord is seated in an **ac** power outlet.
		Check the fuse; replace if defective. It is **.75A**, Slow blow (Figure 7-6).
Emission indicator does not Illuminate at power turn-on	Lamp burned out	Replace the lamp. If the problem is still present, the instrument power supply transformer or Monitor assembly transformer may be at fault.
No light is emitted from the polarizer aperture	The Beam attenuator is closed	Check the position of the attenuator; if it is closed, **PULL TO OPEN IT**.
	Defective laser or laser power supply	Need the replacement / alignment of a laser or removal of instrument power supply for repair (contact **Gaertner**).
No **LED** meter reading during the sample table alignment	No **PD** output (verify at red test jack on electronic chassis)	If the **PD** output is correct, the **LED** meter may be defective.
		If the **PD** output is incorrect, the **PD** board may be defective. Remove the PD board for analysis / replacement.

Table 7-1. TROUBLESHOOTING GUIDE (Continued)

SYMPTOM	POSSIBLE CAUSE	FAULT ISOLATION
The analyzer drum does not rotate (the Mode is at **A**)	There is no motor drive output (assumes no	Observe the motor pulse output at the brown test jack (Figure 7-3). If it is proper, the motor board may be defective.
		If the motor pulse is incorrect, observe the encoder output at check point **A1** (Figure 7-4). If the pulse is correct at **A1**, the **EBT** board may be defective.
		If the pulse is improper at **A1**, measure the voltage at check point **A2**. If the voltage (**+3V dc**) is incorrect at **A2**, the regulator on the buffer / count board may be defective. If it is proper, the encoder may be defective (contact **Gaertner**).

NOTE:
If the EBT board or motor board is found to be defective, remove the chassis assembly for further fault isolation, repair or replacement.

Table 7-1. TROUBLESHOOTING GUIDE (Continued)

SYMPTOM	POSSIBLE CAUSE	FAULT ISOLATION
No binary (**A / D**) data output (all zeros)	The measurement cycle is not initiated	Reset and reload the program. Initiate the measurement. If the symptom persists, observe the reference pulse output at the orange test jack. With the Mode switch at **A**, stall the motor; and look for a pulse around **357°** to **359°** on the analyzer drum. If it is present, verify that the **PCTL** logic **1** (**0** to **1V**) is proper at the blue test jack. If the **PCTL** voltage is correct, the cycle timer may not have turned on. Remove the electronic chassis for trouble analysis of logic board. If the **PCTL** is incorrect, the problem may be in the computer.
		If the reference pulse output is not present (above) at the orange test jack, observe the reference pulse output at check point **A3** (Figure 7-4). If the pulse is present, the Mode switch may be defective.
		If the reference pulse output is not at **A3**, the Optical switch may be defective (contact **Gaertner**).

Table 7-1. TROUBLESHOOTING GUIDE (Continued)

SYMPTOM	POSSIBLE CAUSE	FAULT ISOLATION
No binary data (A / D) output	No PD output conversion	Observe the count pulse output at the yellow test jack. If the pulses are present, check the PFLG pulses at the green test jack. If the PFLG pulses are not present, the logic board may be defective. If the pulses are present, the trouble may be in the computer or the interface cable.
		If the count pulses are not present at the yellow test jack, observe the check point **A4** signal (Figure 7-4). If the pulses are present, the EBT board may be defective. Remove the electronic chassis for analysis / repair.
		If the signal is not proper at **A4**, the encoder may be defective (contact **Gaertner**).
Inconsistent or inaccurate Measurements	Mechanical misadjustment	Verify that the polarizer drum is fixed at **45°**. Check that the polarizer / analyzer settings are in precise agreement. Recheck the table's vertical position.

Table 7-1. TROUBLESHOOTING GUIDE (Continued)

SYMPTOM	POSSIBLE CAUSE	FAULT ISOLATION
Inconsistent or inaccurate measurements (continued)	Irregularity of count pulses	Refer to the count pulse measurement procedure (next page).
	Analyzer drum speed of rotation	Refer to the motor speed adjustment procedure (Subsection 2.5).
	Loss of dual mode operation (the solenoid is not activated to insert the **+90°** compensator into the optical path)	This requires the verification of the **CTL 0** **logic 1** (**0** to **1V**) at the input of the instrument power supply. If the voltage is **3 volts** or more, the trouble is in the computer or the computer interface. If the voltage is less than **one volt** the compensator control board may be defective. The output voltage to the solenoid should be **21** to **24.5V dc** steady state while **CTL 0** is at **logic 1** (to energize the solenoid, with the compensator " **in** "). If the voltage is not correct, remove the power supply for further analysis. If the voltage is proper, then the solenoid is in an " **overheated** " condition or else defective.

1.4 COUNT PULSE MEASUREMENT

a. Place the Mode switch at **A**, and stop the drive motor by a gentle pressure of the hand on the analyzer drum, and then set the analyzer drum to **359°**.

b. Observe the count pulses at the yellow test jack (Figure 7-3) while manually rotating the analyzer drum slowly. The first count pulse should start within **½°** of **0°** and have a duration of no less than **0.4°** or greater than **1.2°**. During the period of the pulse, the voltage should be less than **0.2 volt**, and jump to at least **4 volts** at the end of the pulse. The pulse should repeat at **5°** intervals of the analyzer rotation (a total of **72 pulses** during one revolution of the (drum). Missing and abnormal pulses are an indication of a possible defect in the encoder.

c. To start the automatic analyzer drum rotating, momentarily set the Mode switch at **AS**; and then set it at **A**.

2.0 ADJUSTMENTS

These adjustment should be made by only service personnel.

These adjustments are to be made on two of the three trimpots on the photodetector circuit board in the analyzer. See Figure 7.5 (**A**). The lowest trimpot involves only manual operation.

The **PD Zero Offset**, **LED Meter** and **PD Gain** adjustments are preset at **Gaertner**, but may require readjustment if the photodetector board is replaced.

NOTE

Check the **PD Zero Offset** adjustment
before adjusting for the **LED** meter.

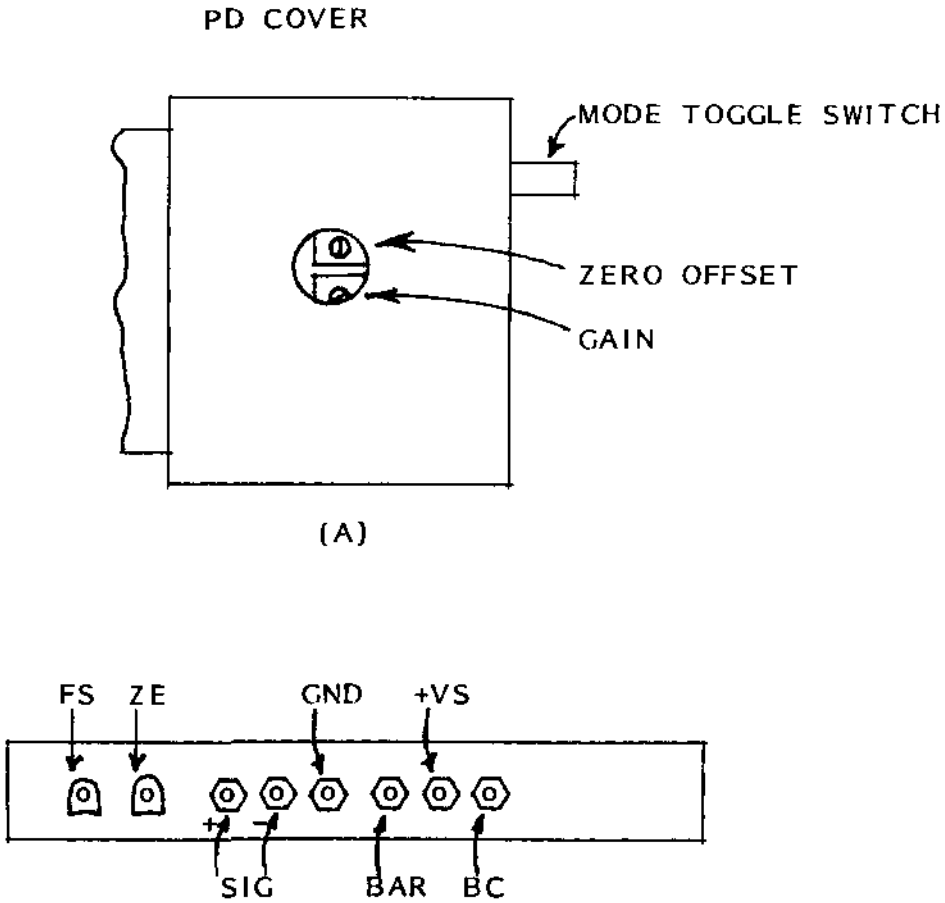


Figure 7-5. **The upper diagram (A) shows the photodetector circuit board in the analyzer module. The lower diagram (B) shows the two trimpots (FS and ZE) and the six voltage test points at the rear of the LED meter.**

2.1 PD Zero Offset

This adjustment can be made by removing the black plug from the side of the **PD** cover.

a. Close the beam attenuator to block the laser light, and set the Mode switch at **AS**.

b. Connect the measuring probe of a voltmeter (that reads **10V** or **20V**, **dc**) to the **PD Output** (**red**) test jack (and the common probe to the **black** common jack in Figure 7-3). Adjust the **Zero Offset** trimpot Figure 7-5 (**A**) as needed so that the voltmeter reads **0.0** volts, dc.

c. Disconnect the voltmeter and reinstall the plug in the **PD** cover unless the gain trimpot adjustment is next.

2.2 PD Amplifier Gain

Turn **OFF** and disconnect the computer from the ellipsometer. (If the ellipsometer has optional Microspot optics **and** the **8"** table, see the next Subsection 2.3.)

a. Set the Mode Switch to **A**. Gently stop the motor with your hand on the analyzer drum.

b. Set the polarizer and the analyzer arms to **90°**, and open the beam attenuator.

c. Slowly rotate the analyzer drum for the maximum **LED** meter reading (should be at **45°**).

d. Adjust the **GAIN** trimpot (**CW** for more gain), Figure 7-5 (**A**), for **93** on the **LED** meter.

e. If the **LED** meter was pegged in the last step, decrease the gain; and rotate the drum for another maximum reading.

2.3 PD Amplifier Gain (With both the Microspot Optics and the 200 mm diameter Table)

Use the **780Å** film layer sample wafer or one of a known film thickness. Set the two arms at **70°**, and adjust the table as needed.

a. Set the Mode Switch to **AS**. Slowly turn the analyzer drum for the maximum **LED** meter reading.

b. Adjust the **GAIN** trimpot (**CW** for more gain), Figure 7-5 (**A**), for **93** on the **LED** meter.

c. Set the Mode Switch to **A**. The drum should turn while the **LED** meter reads **23**, maximum.

2.4 LED Meter

With the beam attenuator closed, and the polarizer and analyzer arms at **90°** and the Mode Switch at **AS**, follow these four steps:

a. The **LED** display should show one to three red light dots for **the zero** reference. If the meter does not, adjust the **ZE** trimpot, Figure 7-5 (**B**), so that there is a two-dot display.

b. Open the beam attenuator.

c. Connect a voltmeter common probe to the **ground** (**black**) test jack in Figure 7-3, and connect the measuring probe to the **PD** Output (**red**) test jack. Slowly rotate the analyzer drum until the voltmeter reads **10V**, **dc**.

d. Adjust the **FS** trimpot as needed so that the **LED** meter reads **100** (as the voltmeter reads **10V**).

2.5 Motor Speed

This adjustment is just to the right of the Motor Pulse (brown) test jack (Figure 7-3). The motor speed control trimpot is preset at the factory, but may require a fine adjustment if the electronic chassis is replaced, to ensure accurate measurements of very thin films. A silicon substrate with a silicon oxide film layer of around **200Å** (**20 nm**) is recommended for this adjustment.

a. With the polarizer and analyzer arms set at **70°** angle of incidence and a sample in place, adjust table vertical position according to Subsection 1-3, " Sample Table Vacuum and Alignment " in Section 2, Operation.

b. Refer to the " The Sample Table Vacuum and Alignment " section in the **STD** instructions, and use the same program or subprogram.

c. Adjust the motor speed trimpot ¼ **-turn** counterclockwise, and rerun the program (or subprogram) to obtain a second set of measurements.

d. Adjust the motor speed control ¼ **-turn** clockwise from the initial setting used to obtain measurements obtained in step **b**, and rerun the program to obtain a third set of measurements.

e. Compare the measurement data obtained in step **c** and **d** with the measurement data obtained in step **b**. The differences should not vary more than **3** to **5Å** (**.3** to **.5 nm**).

2.5 **Motor Speed** (Continued)

f. If the difference is greater than **3Å** to **5Å**, repeat the variation of speed adjustment and measurements until the measurements are within **3Å** to **5Å**.

g. When the adjustments are complete, the motor should run smoothly.

CAUTION

A void changes in the motor speed that would induce excessive vibration.

2.6 **A / D Offset**

This adjustment is just to the left of the **red** (**PD** Output) test jack on the electronic chassis. The **PD ZERO** offset is preset at the factory but may require adjustment if the electronic chassis is replaced, to ensure measurement insensitivity to **PD** output changes in gain level. An indication of sensitivity is apparent when repeated thickness measurements on the same sample, particularly one with a very thin film, vary more than **3Å** to **5Å** (**.3** to **.5 nm**). A silicon substrate with silicon oxide film of about **550Å** (**55 nm**) is recommended for this adjustment.

2.7 **Optical Orientation Checks***

Periodically perform an optical orientation check as follows:

a. Set the Mode Switch (on the analyzer module) to **M**.

NOTE

If the ellipsometer is equipped with the Optional Microspot Optics, remove the Two microspot stops. See Figure 7-6.

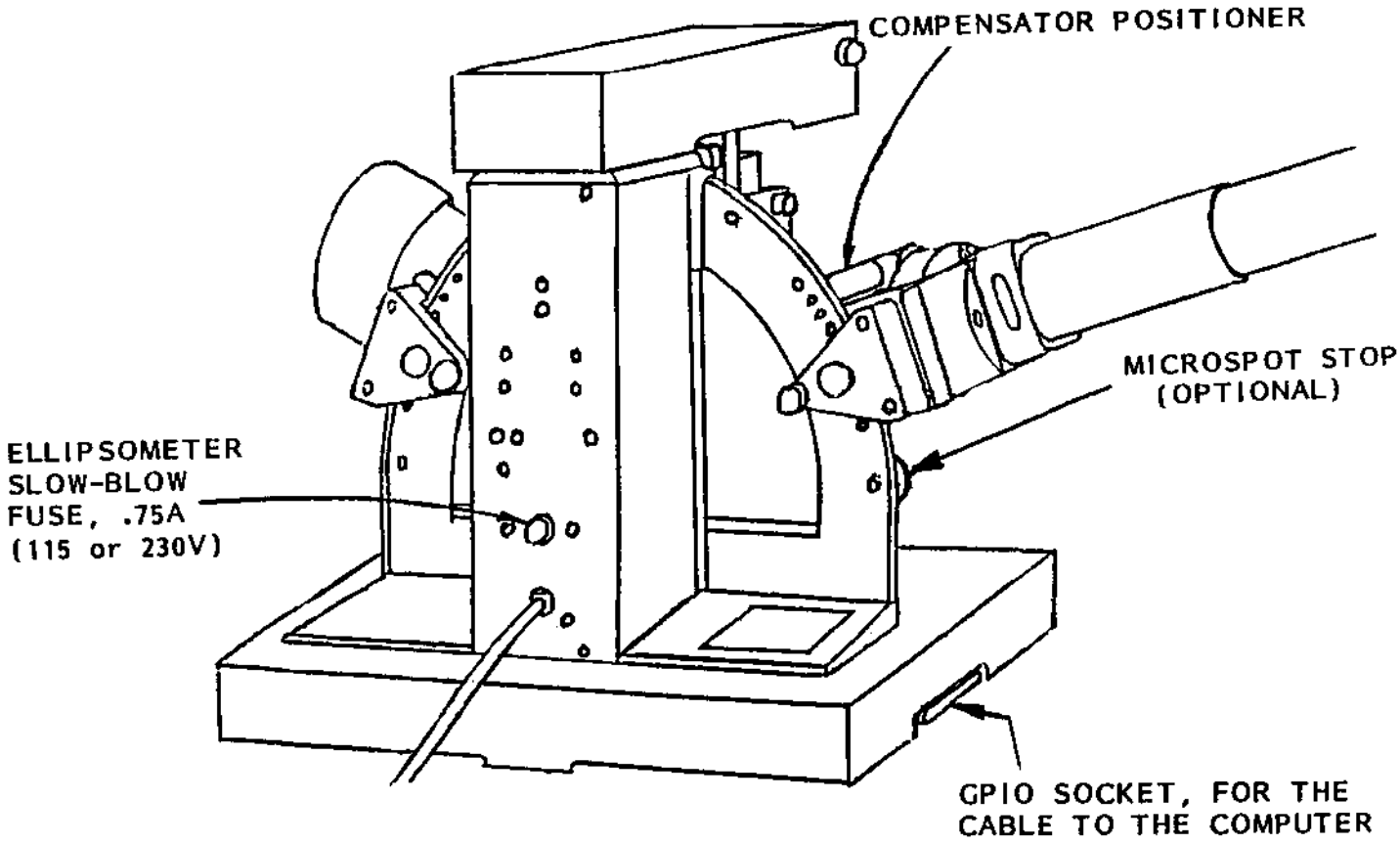
b. Close the beam attenuator, and lower the sample table fully.

* **These checks cannot be used with an instrument with both the 200mm diameter table and the Microspot Optics, because the table cannot be moved out of the way of the optics to set the arms at 90°.**

(Section 2-7 continued on page 7-19)

CAUTION (For 90° Angle of Incidence)*

If the ellipsometer has Mocrospot Optics, turn the table so that its notch (lifting slot) is under the analyzer arm. Move the table to the left and down so that neither Microspot Optic will touch the table when the arms are at 90°.



* The optional 200 mm dia. table cannot be moved out of the way of the optional Microspot Optics. Thus, the arma cannot be set at 90° with both options.

Figure 7-6. This is the rear and left view of the L116C.

2.8 Optical Orientation Checks (Continued)

c. Place the polarizer and analyzer arms at a **90°** angle of incidence.* Clamp the arms in place.

d. Remove the **45°** locking screw from the polarizer drum. Open the beam attenuator.

NOTE: **Push in and hold the automatic compensator positioner for steps e through g. The +90° compensator is in the optical path. See Figure 7-7, next page.**

e. Set the polarizer drum exactly at **180°** and the analyzer drum precisely at **90°**.

f. Observe the **LED** meter, and rotate the analyzer drum slowly to a setting at which the LED meter indicates the lowest reading. This occurs when the analyzer drum setting is at **90° ±0.4°**.

g. Set the analyzer drum exactly at **90°**. With the polarizer drum set precisely at **180°**, observe the **LED** meter, and rotate the polarizer drum slowly to a setting at which the **LED** meter indicates the lowest reading. This should occur when the polarizer drum setting is **180° ±0.4°**.

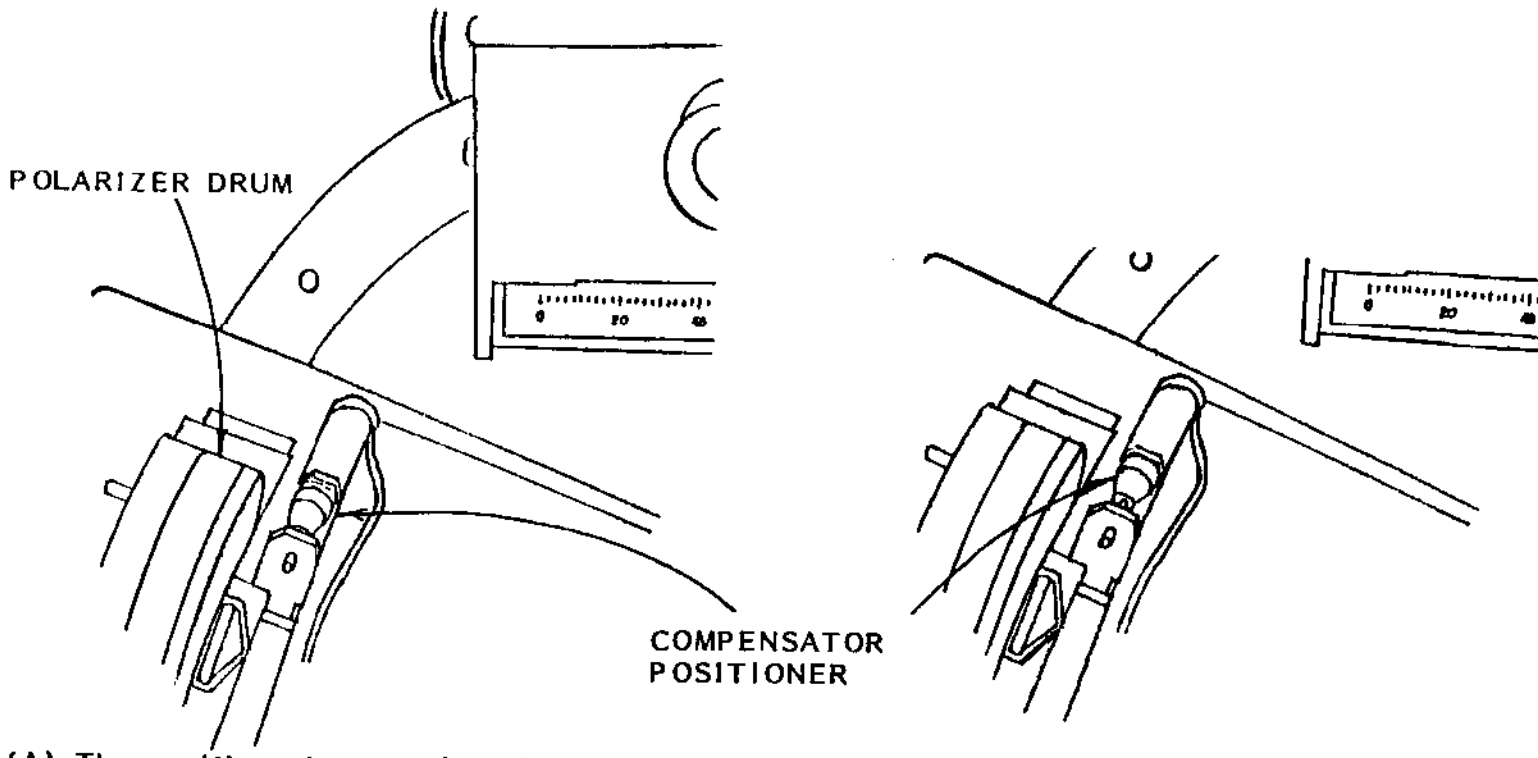
NOTE: **If the drum settings in steps f and g are within the specified limits, the compensator is properly oriented.**

h. Set the polarizer drum at **45°**; then insert and tighten the drum locking screw.

i. Set the analyzer drum to the position where the LED meter has the lowest reading. This should occur where the analyzer drum setting is **135° ±0.4°** or **315° ±0.4°**. If the analyzer drum setting is within either of these limits, the analyzer prism is properly oriented.

j. Close the beam attenuator, and fix the polarizer and analyzer arms at a **70°** incidence angle.

*** If the ellipsometer has both the Microspot Optics and an 8" diameter table, the table can't be moved out of the way to set the arms at 90°. Thus, ignore this Subsection " Optical Orientation Checks ".**



(A) The positioner's normal position has the +90° compensator out of the light path

(B) The positioner pulled back has the +90° compensator in the light path.

Figure 7-7. This is the automatic compensator positioner on the right end of the polarizer arm.

2.7 Optical Orientation Checks (Continued)

k. Set the Mode Switch to **AS**, and open the beam attenuator.

NOTE:

Reinstall the two optional microspot stops. See Figure 7-6.

l. Adjust the table to the proper vertical position according to the " **Sample Table Vacuum and Alignment** " procedure, in the Operation Section (**2**) of this manual.

3.0 COMPONENTS REMOVAL FOR REPAIR / REPLACEMENT

The removal instructions are limited to service personnel. These instructions apply to components requiring either direct replacement or lower-level fault isolation and repair. Removal of components other than those covered herein should be performed only by **Gaertner** personnel.

3.1 Instrument Power Supply

The ellipsometer power supply consists of the following:

- **Laser Power Supply**
- **+5V dc Power Supply for the LED Meter**
- **Compensator Control Board**
- **Multi- Purpose Transformer:**

  115V ac for the Sample Monitor Assembly

  115V ac for the Instrument dc Power Supply and Laser Power Supply

  28V ac for the Compensator Control Board

The stansdard instrument power supply accepts **115V ac rms** line voltage, but can be modified to operate with **100V**, **220V**, **230V** or **240V ac** input line voltage.

a. Turn OFF the computer and ellipsometer. Unplug the ellipsometer line cord from the **ac** power.

b. Detach the instrument power supply from the vertical support panel of the ellipsometer by removing four mounting screws, one at each corner of the power supply base plate. Lower the power supply horizontally on a padded support block. The padding helps avoid damage to painted surfaces.

WARNING

Exercise care in performing step **c**, as high voltage (up to **10,000 volts**) is in the **632.8 nm** laser assembly.

c. Unplug the white laser plug from the laser power supply receptacle. Discharge the laser voltage by shorting out the two-prong plug with a **1K**-to-**2K** resistor.

3.2 LED Meter Assembly

Remove the LED meter and the **8-inch** cable at the rear of the meter by performing the following:

a. Turn OFF computer and ellipsometer. Unplug the line cords from the ac power outlet.

b. Remove four screws from the top cover of the sample monitor assembly housing, and remove the cover for access to the cable connection.

c. Disconnect the LED meter cable from **4"** monitor-to-power supply extension cable connector.

d. Support the LED meter while removing two screws that secure the meter to the underside of the Sample Monitor Assembly.

e. Remove the meter while removing the cable through the hole in the Sample Monitor Assembly Base.

f. To replace or reinstall an **LED** meter assembly, reverse the procedure of steps **b** through **e**.

g. Support meter assembly while removing three mounting screws that secure meter assembly to support arm. This completes removal of the meter assembly and interconnecting wiring.

h. To replace a meter assembly, reverse the procedure of steps **b** through **g**.

3.3 Electronic Chassis

The electronic chassis contains the following:

- **Motor Board**
- **EBT Board**
- **Logic Board**
- **Analog-to-Digital (A/D) Board**
- **±15V dc Power Supply for the A/D Board and Photodetector Board**
- **+5V dc Power Supply for the A/D Board, Logic Board and Count Board**
- **+1-V dc Power (two 5V supplies in series) for the Motor Board**

3.3 **Electronic Chassis** (Continued)

Color-coded test jacks and motor speed and **A / D** offset adjustments are on the right side of the chassis. (See Figure 7-3.) The computer Interface Cable receptacle is on the chassis left side. The removal of the electronic chassis requires the removal of the instrument power supply for access to the connections of the chassis Interface Wiring.
Perform the following:

a. Turn **OFF** the computer and ellipsometer. Unplug the ellipsometer line cord from the **ac** power.

b. Disconnect the computer **GPIO** Interface Cable from the Electronic Chassis.

c. Detach the instrument power supply from the support panel, as instructed in step **b** of the instrument power supply removal procedure (above).

d. Disconnect the **3** - and **4** – pin electronic chassis Interface Wiring connectors in the power supply.

e. Remove the two screws from each side of the ellipsometer base to detach the electronic chassis from the base.

3.4 Photodetector Board

The removal of the photodetector board requires access to the detector and switch assembly. Perform the following:

a. Turn **OFF** computer and ellipsometer. Unplug line cord from **ac** power outlet.

b. Remove the two screws that secure Mode switch to cover of detector and switch assembly.

c. Loosen the three screws that secure the cover. Pull the cover outward to remove it from the assembly.

d. Withdraw the switch assembly from retainer slots and disconnect the two black / white plugs from the receptacles above the photodetector board.

e. Remove the four screws that secure the photodetector board, and lift out the board carefully.

f. To install a photodetector board, reverse the procedure of steps **b** through **e**.

3.5 Beam Attenuator

This procedure applies to both the removal and reinstallation (or replacement) of the beam attenuator.

Perform the following:

a. Loosen table clamp screw, and lower the table fully.

NOTE: Remove the optional microspot stops from the vertical plate (Figure 7-6). Observe the **NOTE** at the top of the figure.

b. Position the polarizer and analyzer arms at **90 degrees** angle of incidence.

c. Using a **5/32-inch** hex key, remove the two cap screws that secure polarizer pin-hole plate to the inner support of polarizer arm.

3.5 **Beam Attenuator** (Continued)

d. Pull the pin -hole plate (with the optional microspot optics) from support. Remove the inoperative beam attenuator from the slotted back surface of plate and install new beam attenuator in slot, noting that orientation is the same as for the one removed. (The end with a hole toward the front.)

e. Install the pin-hole plate (with the optional microspot optics) on the support, using the locating pins as a guide and ensuring that the silver reference dots on pin-hole and polarizer inner support are aligned.

f. Insert the two cap screws (removed in step **c** above) into the holes in the pin- hole plate. Turn them until they are almost finger tight Check the plate and locating pins for firm seating and then tighten the screws, using **5/32-inch** hex key.

g. Slide the attenuator **in** and **out** to verify that there is no binding. (If it is too loose, bow the slide slightly.)

h. Position the polarizer and analyzer arms at the **70°** angle of incidence. Reinstall the optional microspot stops.

i. Adjust the table for the desired vertical position in accordance with the Sample Stage or Table Alignment procedure (in the Operation Section).

4.0 COMPUTER INTERFACE CABLE DATA

Computer interface cable data for the ellipsometer is contained in **Table 7-2**.

5.0 REPLACEMENT PARTS

A replacement parts list is in the **Table 7-3**.

Table 7-2. L116C Computer Interface Cable Data

Pin No.	Input	Output	Logic Level	Function
1,18,24,26,43,49	——	——	——	Ground
3		X	1	A/D, Bit 1(MSB)
4		X	1	A/D, Bit 2
5		X	1	A/D, Bit 3
6		X	1	A/D, Bit 4
7		X	1	A/D, Bit 5
8		X	1	A/D, Bit 6
9		X	1	A/D, Bit 7
10		X	1	A/D, Bit 8
11		X	1	A/D, Bit 9
12		X	1	A/D, Bit 10
13		X	1	A/D, Bit 11
14		X	1	A/D, Bit 12 (LSB)
19		X	1	A/D Done, (reading ready)
44	X		1	Initiate Measuring Cycle*
44	X		0	Terminate Measuring Cycle*
47	X		1	Compensator In
47	X		0	Compensator Out
48	X		1	Increase PD Gain
48	X		0	Decrease PD Gain

* **The Period of the measurement cycle is one revolution of analyzer drum, with the duration settable from 0.25 to 1.5 seconds.**

Logic Levels (TTL): Logic 1=0 to 1 volt; Logic 0=3 to 5 volts.

Table 7-3. L116C Replacement Parts List

Nomenclature	GSC Part No.
Electronic Chassis	10161-KB
Interface Connector (Chassis)	A-7108-E118B
Mating Connector (Cable)	A-7108-E118A
Test Jack	7108-E127 (Specify Color)
Instrument Power Supply	10026-KF with 10161-B15
Meter and Cable Assembly	10257-21
Photodetector Board	10257-10E
Mode Switch (Includes Cables and Connectors)	10257-30
Beam Attenuator	10026-21
A/D Offset Potentiometer	A-7108-E121
Motor Speed Potentiometer	A-7108-E121
Emission Indicator Lamp	7108-E266
Lock Switch (Includes key)	7108-E231A
Ellipsometer Fuse, ¾ Amp, SLO-BLO	B-7108-E138
Clamp Screw (Sample Table)	10026-A5
Clamp Screw (Polarizer / Analyzer Arm)	10026-15P
Clamp Screw (Polarizer Drum)	10161-C8 with 10161-C10-RE1
Illuminator Bulb (Sample Monitor)	M230-F46
Transformer, Monitor Assembly	7108-E230A
Cable, Monitor / Power Supply Extension	10259-23M
Laser Assembly (632.8 nm)	C-10026-20EN